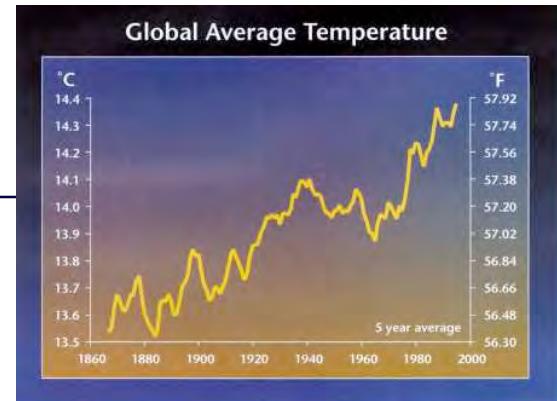


Effects of climate variation on mosquitoes and arboviruses in California

William K. Reisen
Center for Vectorborne Diseases
School of Veterinary Medicine
University of California, Davis



Acknowledgments

□ Collaborators

- Chris Barker, Bruce Eldridge & Bborie Park, Center for Vectorborne Diseases, UC Davis
- Dan Cayan, Mike Dettinger, Mary Tyree, Scripps Institute of Oceanography, UC San Diego
- Mosquito and Vector Control Association of California
- California Department of Health Services
- CDC ArboNet

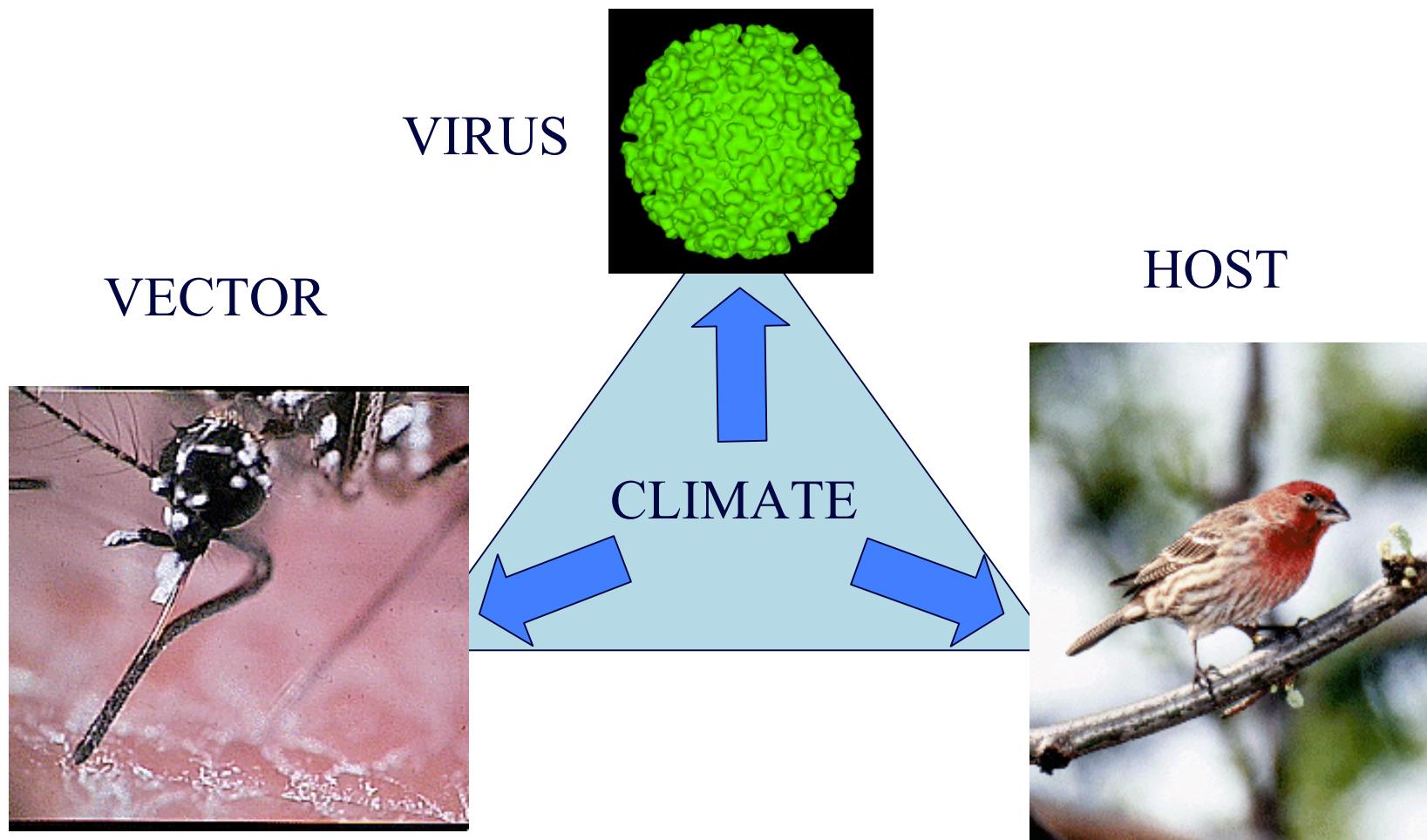
□ Funding

- Office of Global Programs, NOAA
- National Institutes of Health
- NASA Space and Earth Science

Content

- Importance of temperature
 - Mosquito biology [larval development, survival, blood feeding]
 - Virus transmission [rate of amplification]
- Warming temperature
 - Increases season length – change in water availability
 - Increases the range for transmission by latitude and elevation
- Water
 - Required for mosquito production
 - Too much or too little can result in reduced mosquito populations
 - Effects of shore line changes on coastal marshes
 - Ecosystem dynamics, primary productivity and bird population dynamics

CLIMATE EFFECTS ALL COMPONENTS OF ARBOVIRUS TRANSMISSION CYCLES

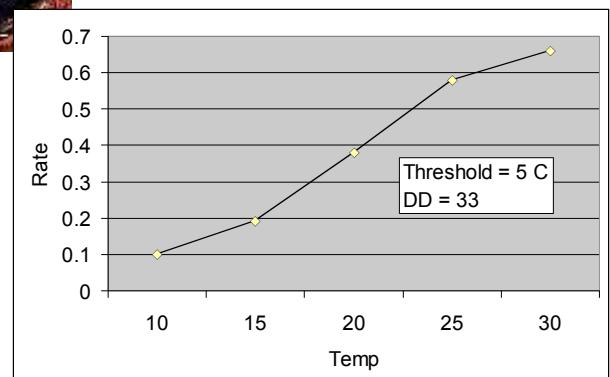
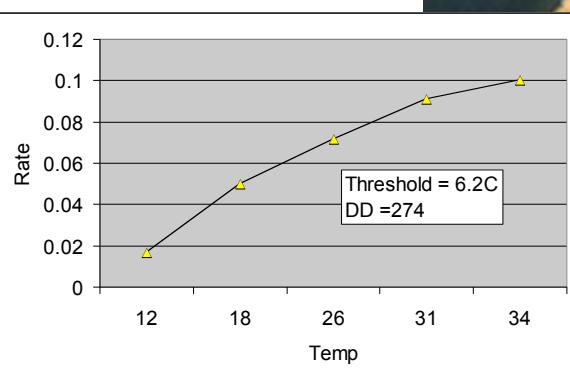


Effects of temperature on mosquito life cycle

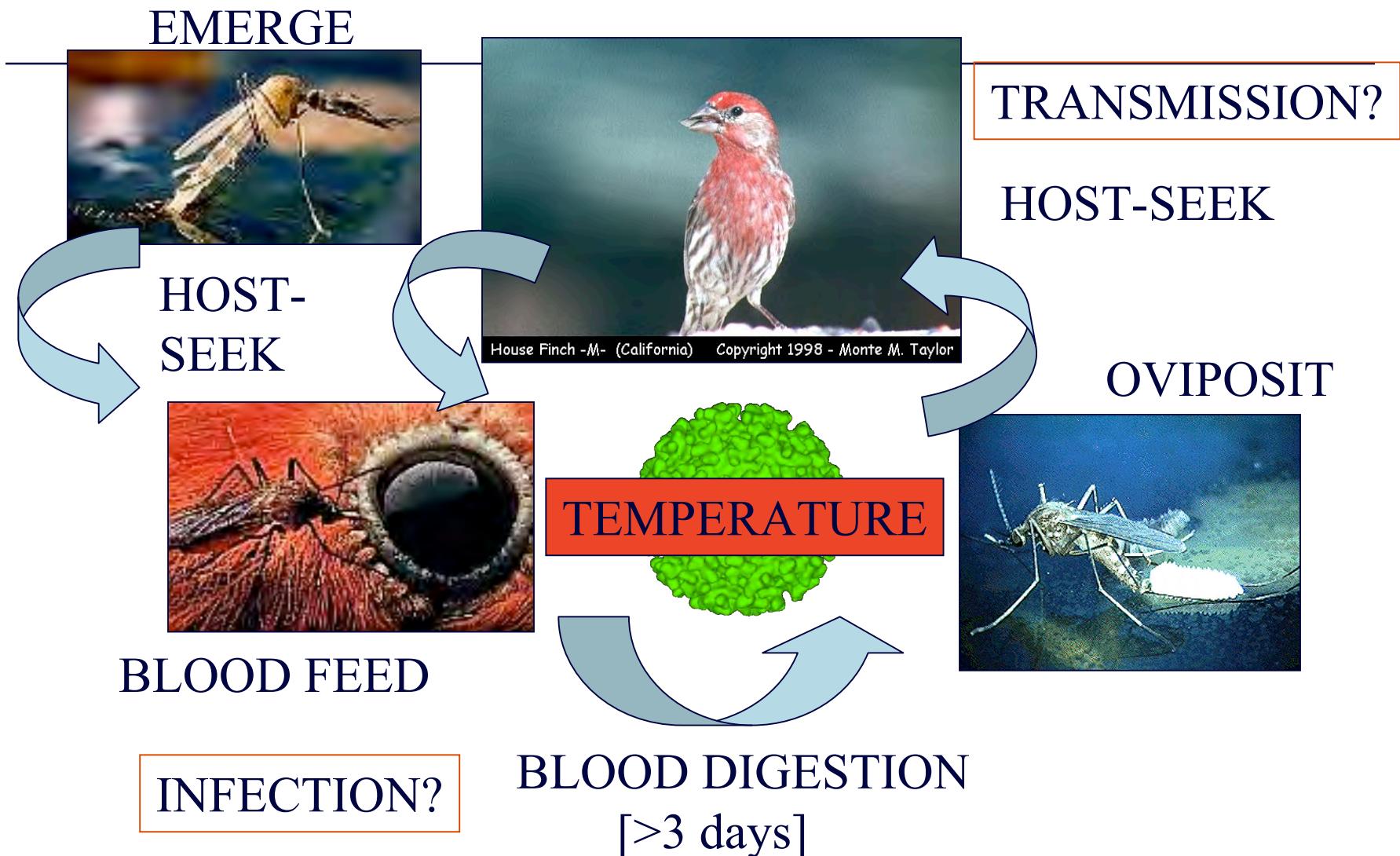
Aquatic stages



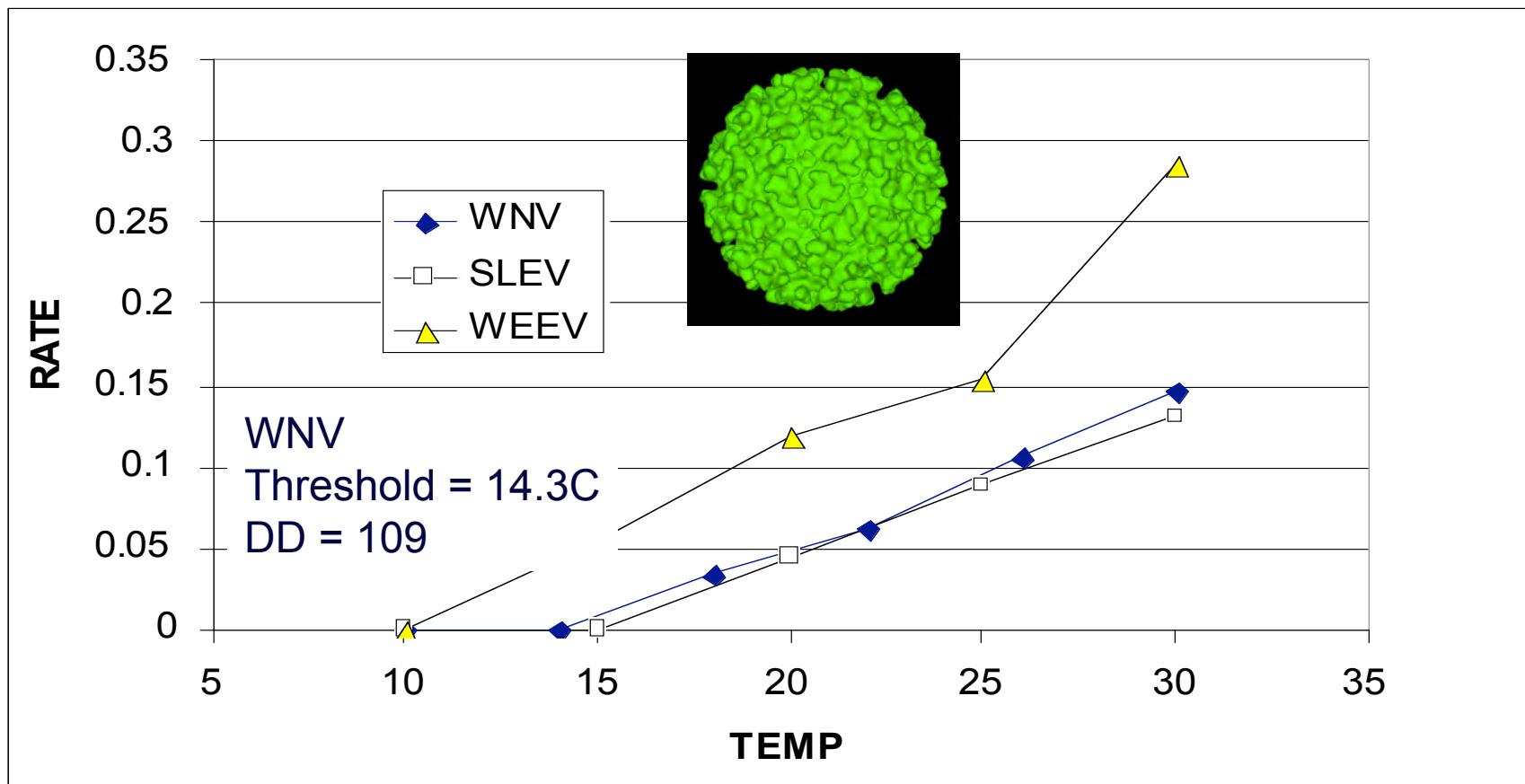
Terrestrial stages



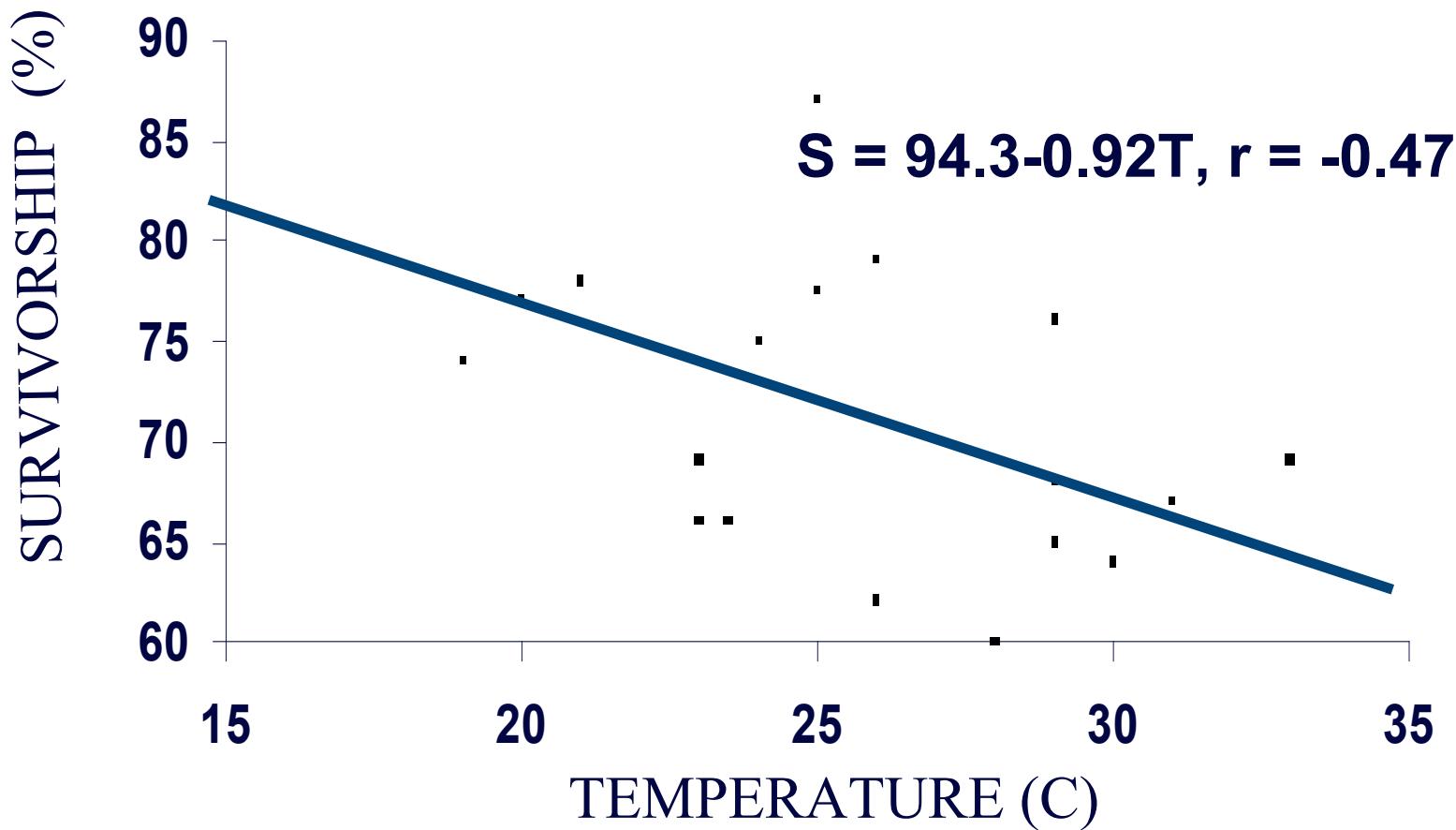
Mosquito-borne pathogen transmission: Gonotrophic cycle and transmission



Rate of EIP for three encephalitis viruses plotted as a function of incubation temperature

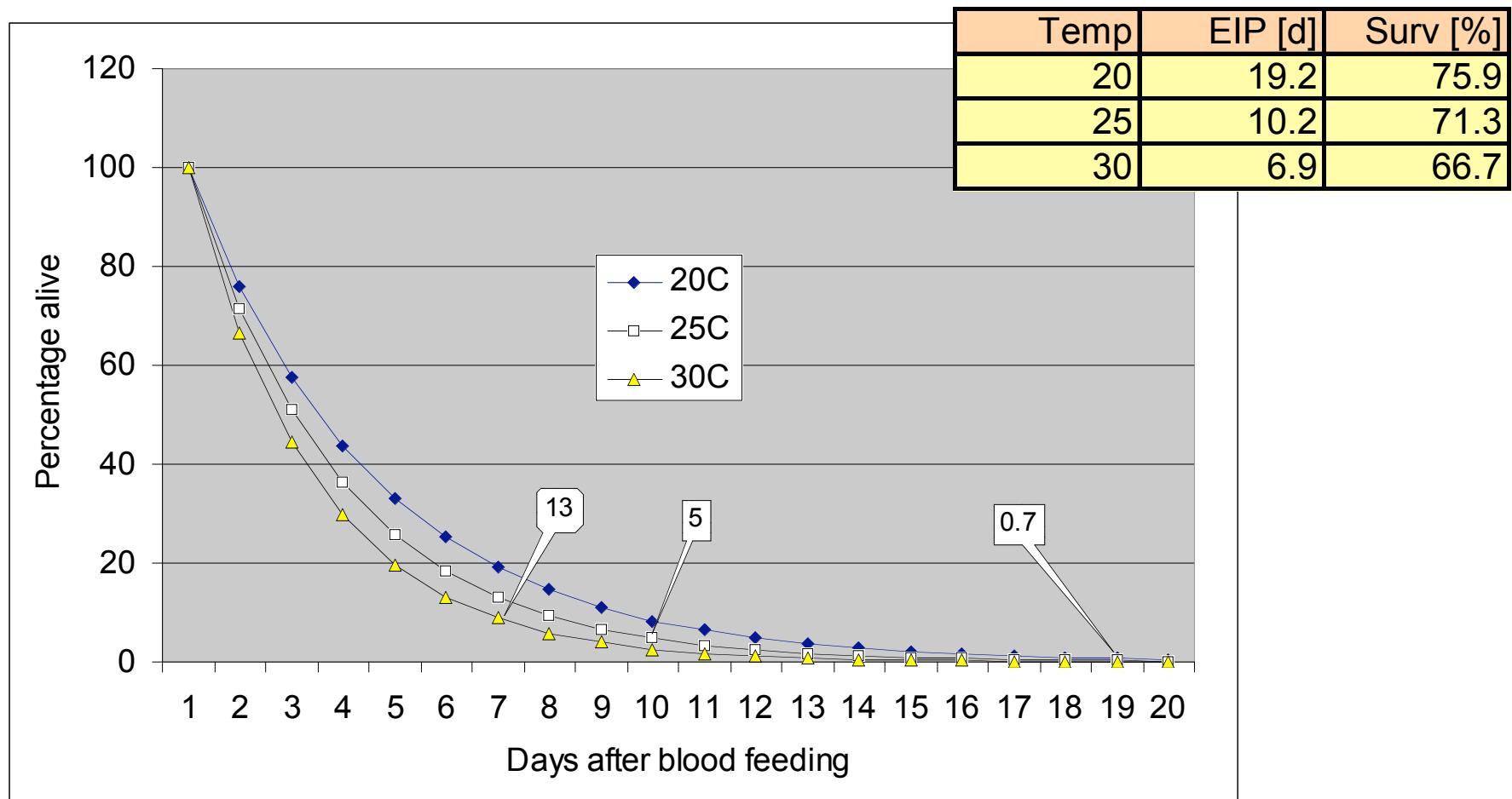


EFFECTS OF TEMPERATURE ON ADULT *CX. TARSALIS* SURVIVORSHIP



REEVES ET AL. 1994. JME 31: 323

Effects of temperature on number of infected females alive to transmit at the end of the extrinsic incubation period



TIME SCALES OF CLIMATE VARIABILITY

short

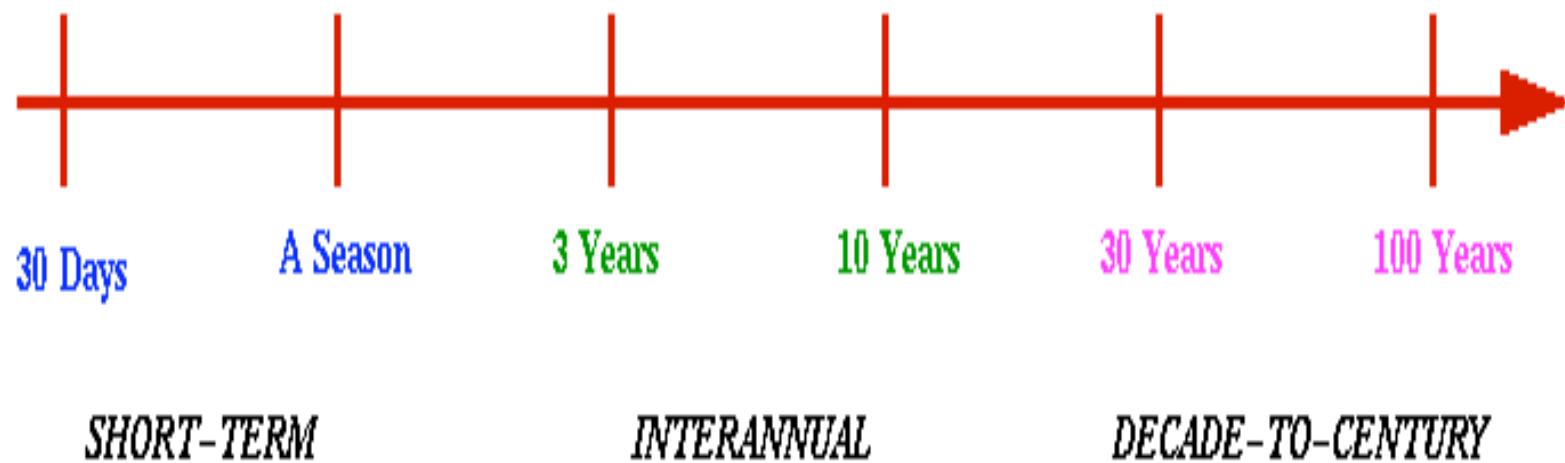
- Heat waves, droughts
- Floods
- Storm track variations
- Madden-Julian Oscillation

intermediate

- El Niño-Southern Oscillation

long

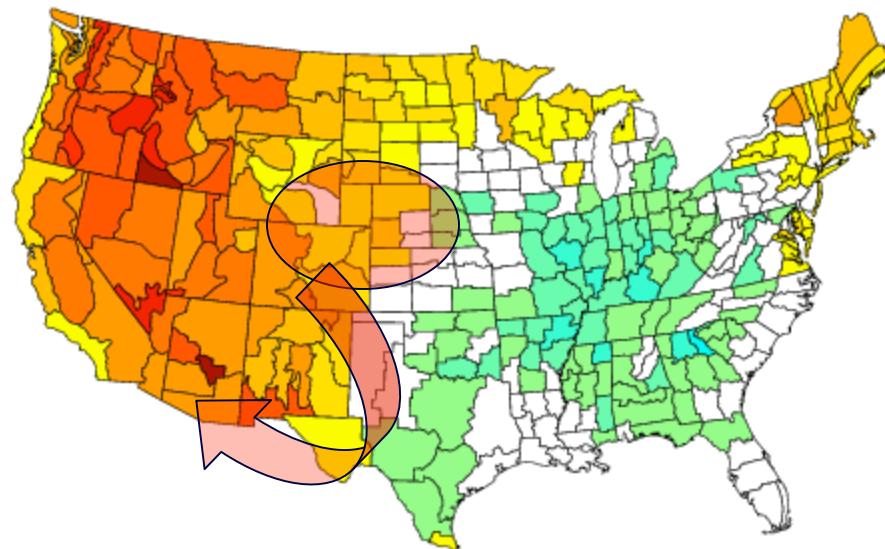
- Decadal variability
- Solar variability
- Deep ocean circulation
- Greenhouse gases



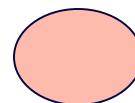
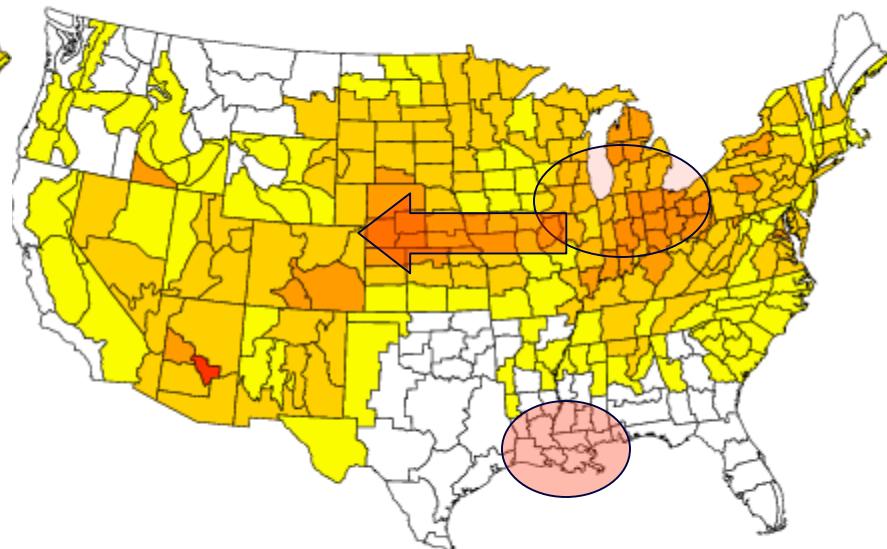


Summer temperature anomalies for 2002 and 2003

Composite Temperature Anomalies (F)
Jun to Sep 2003 to 2003
Versus 1971–2000 Longterm Average



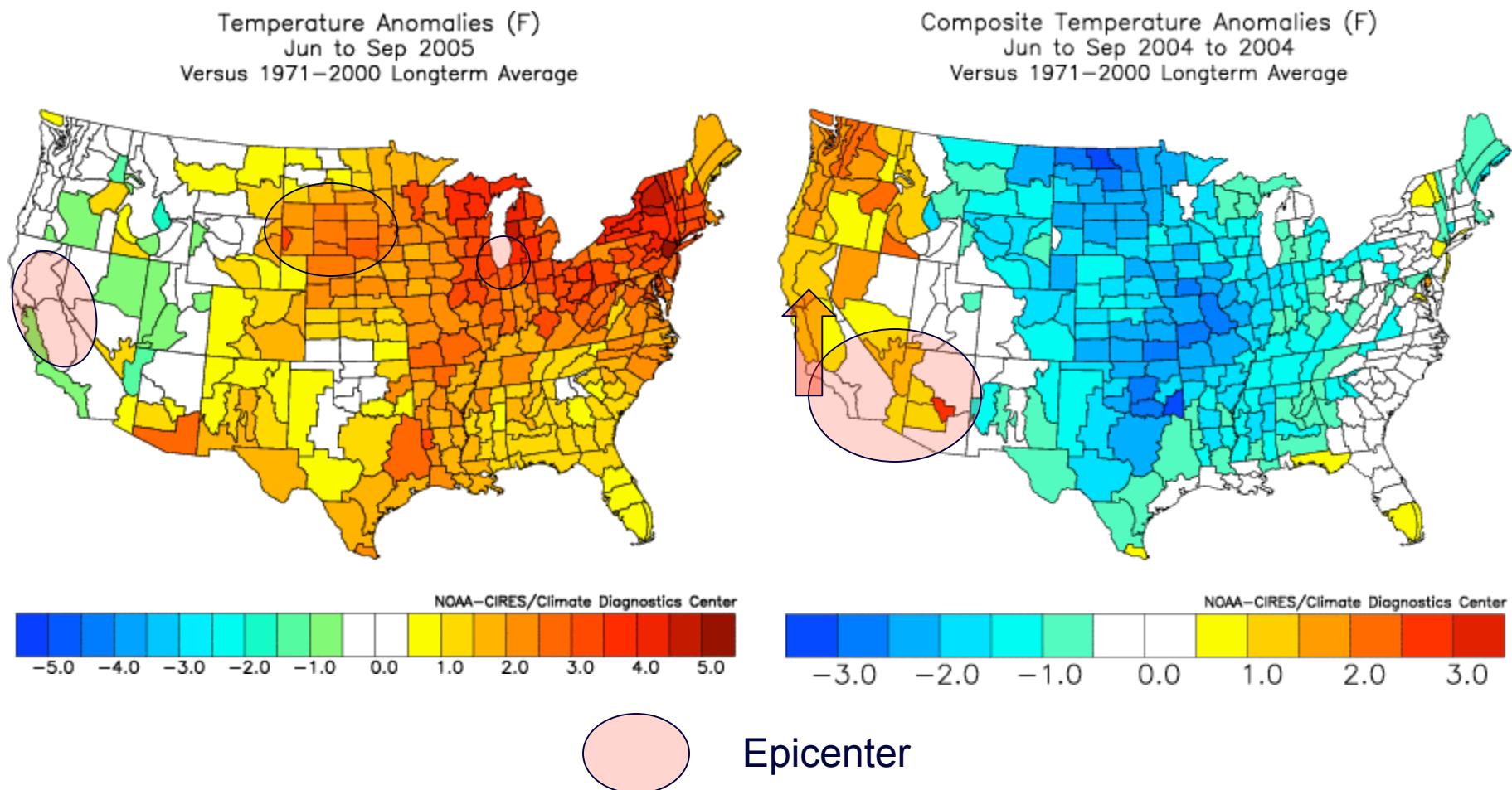
Composite Temperature Anomalies (F)
Jun to Sep 2002 to 2002
Versus 1971–2000 Longterm Average



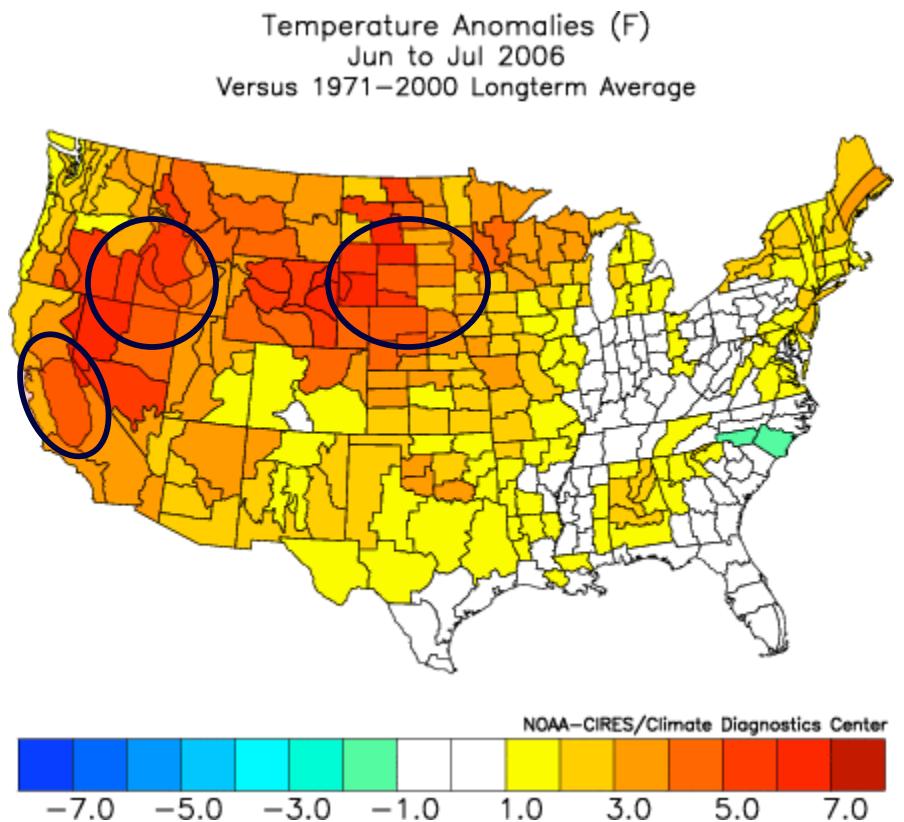
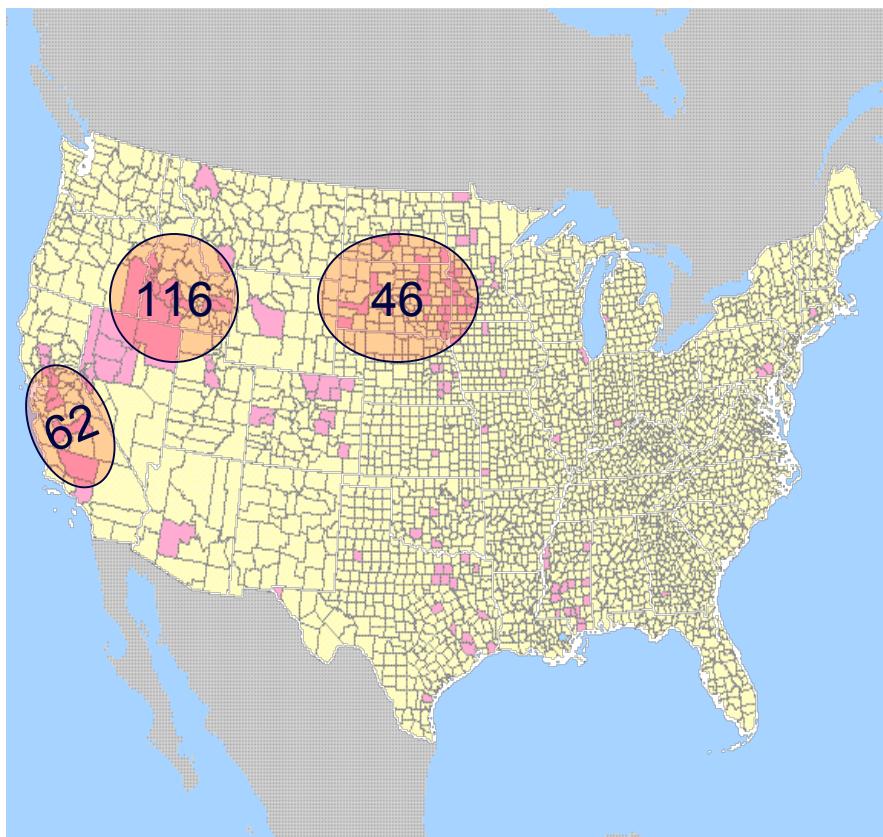
WNV epicenters



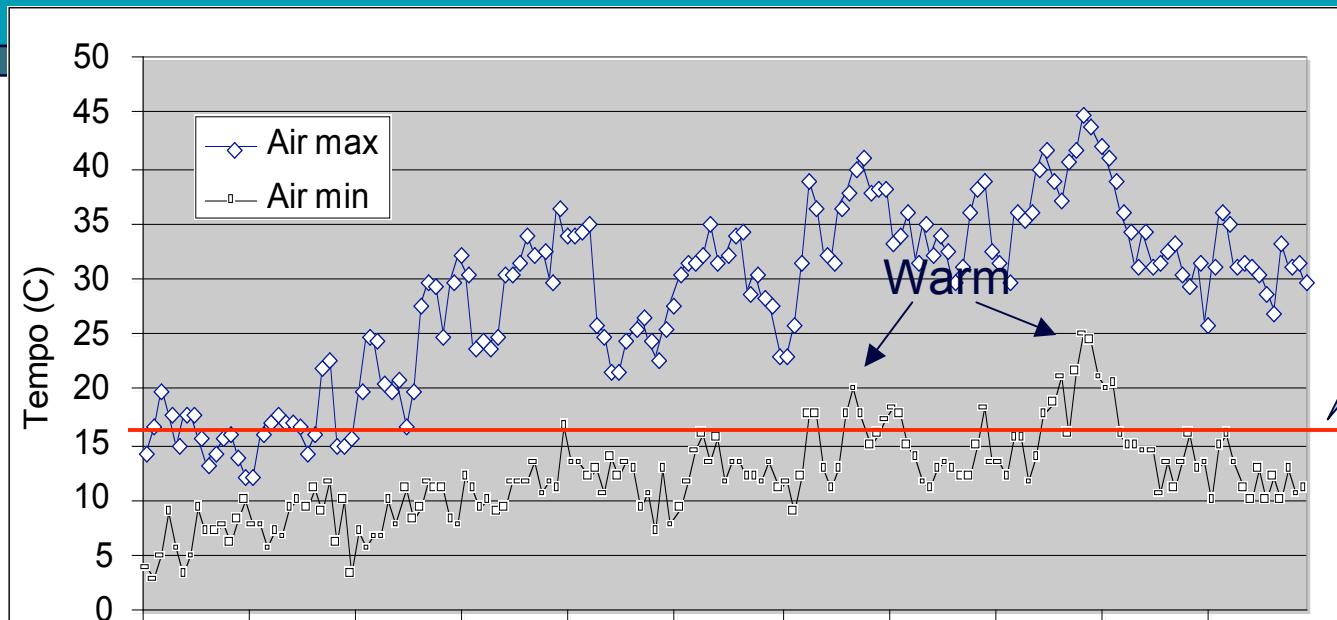
Composite temperature anomalies for summer of 2004 and 2005 with WNV epicenters shown within circles



Case data and temperature anomalies for 2006

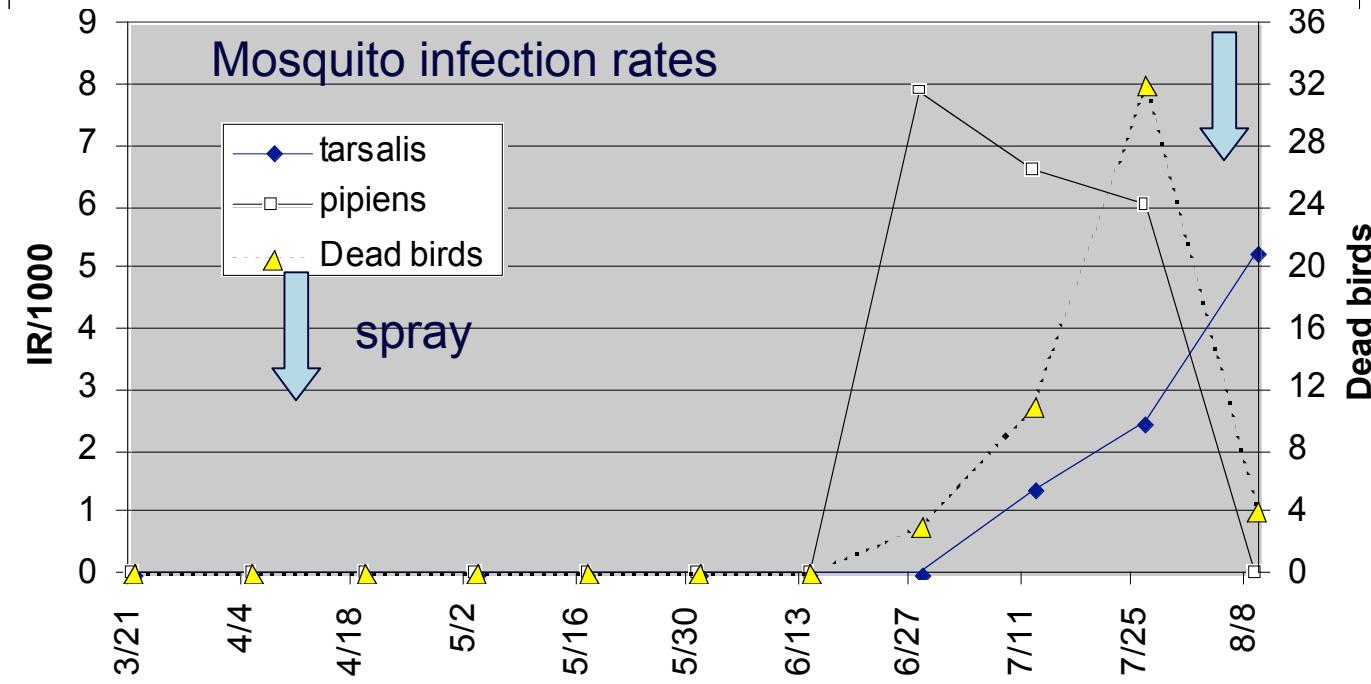


Locations of human cases [22 Aug];
largest epidemic so far in Idaho



Minimum threshold for WNV replication

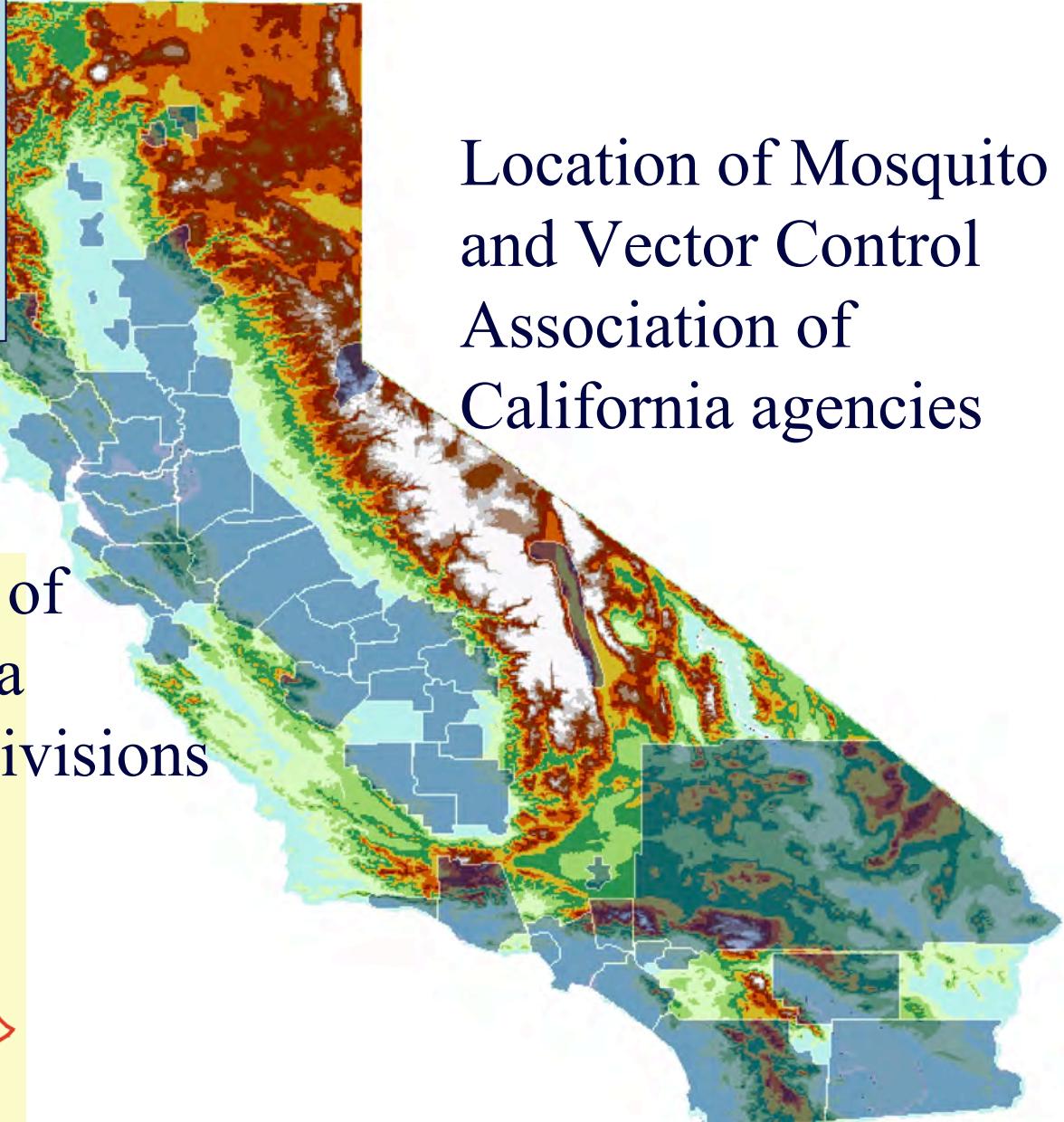
Importance of warm evening temperatures in the epidemiology of WNV in Davis, Yolo County, California



USE OF CLIMATE VARIATION TO FORECAST MOSQUITO ABUNDANCE

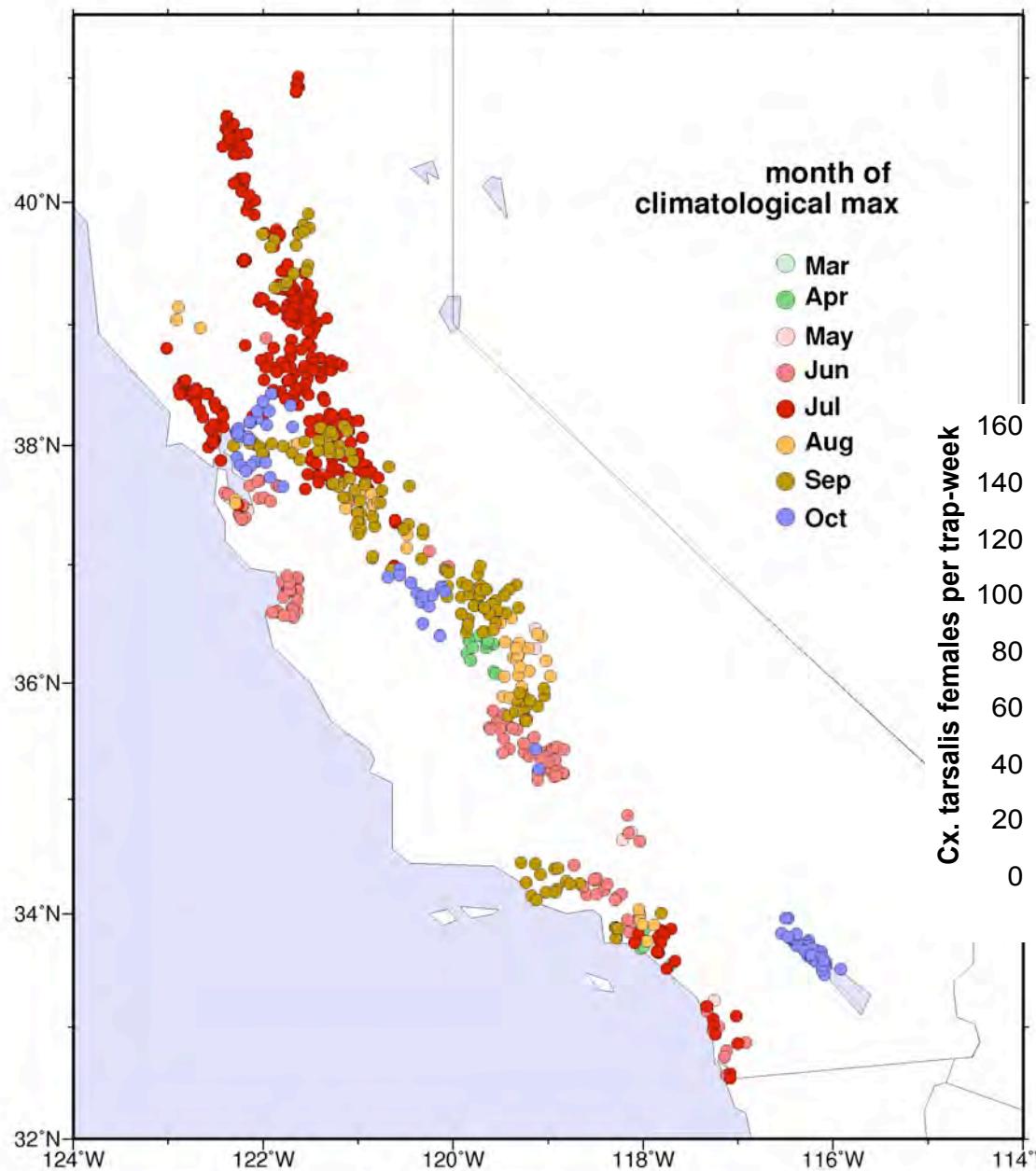


Location of California climate divisions

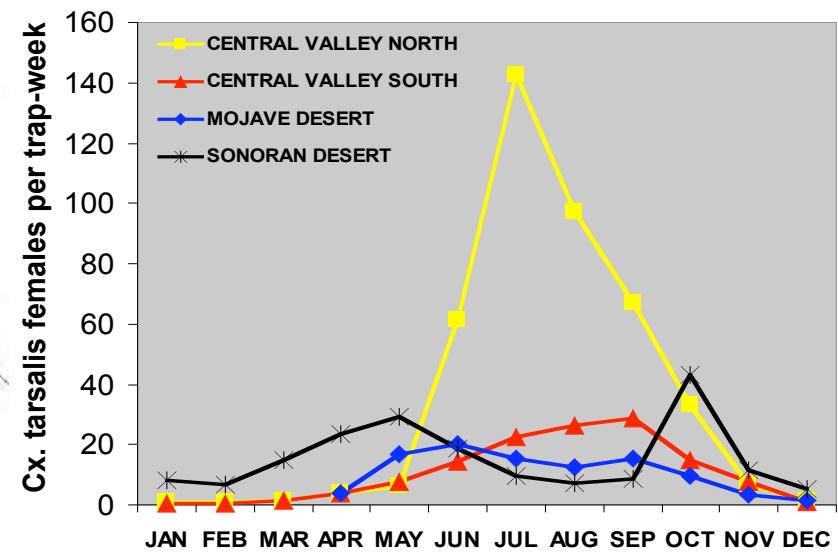


Location of Mosquito and Vector Control Association of California agencies

Cx female *tarsalis* (min 5 yr record)
34 districts (677 sites)

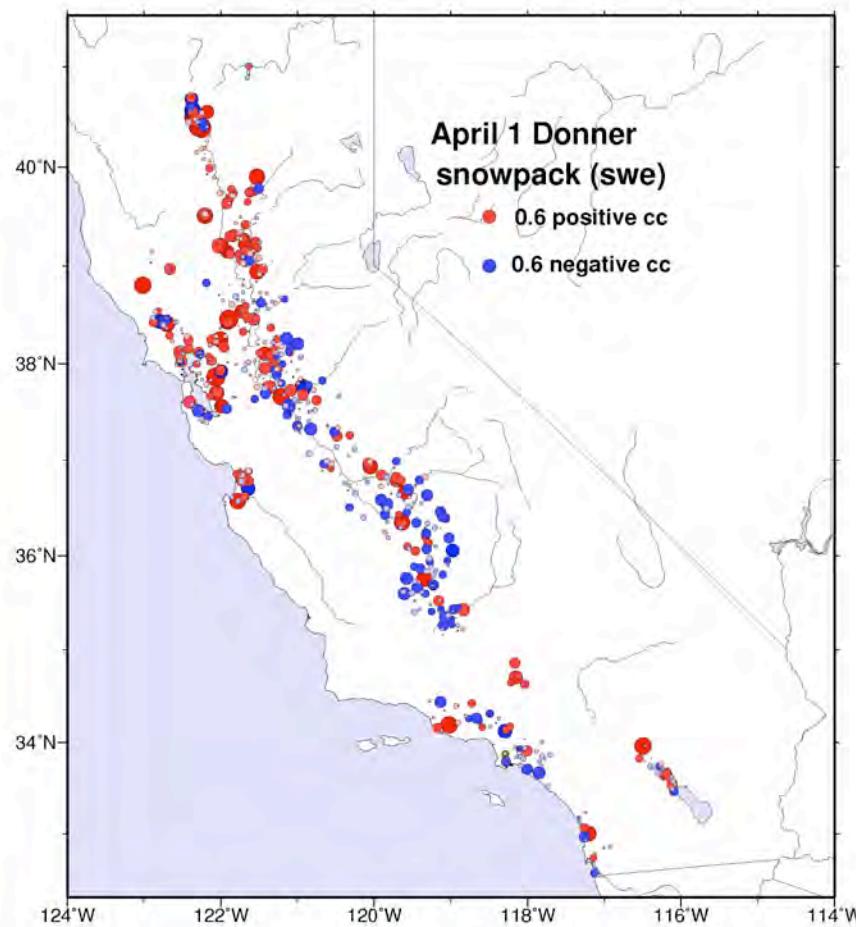


Variation in the
seasonality of *Cx.*
tarsalis populations
in California

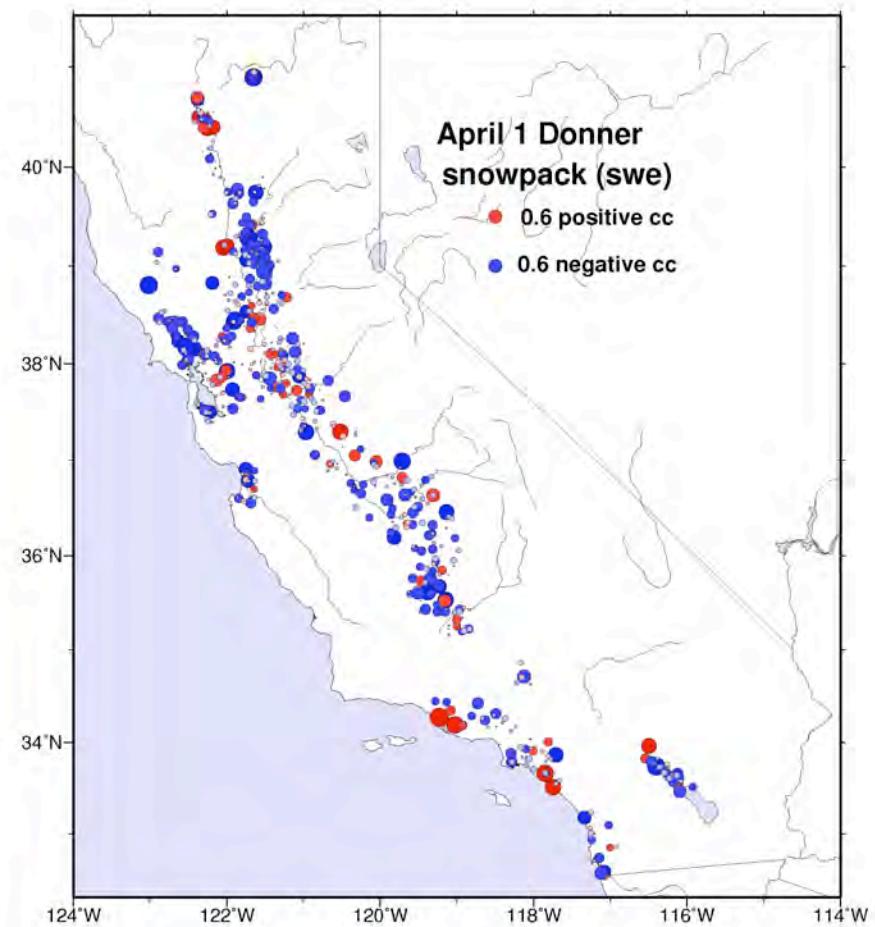


Cx tarsalis abundance during spring [left] and summer [right] as a function of 1 April snowpack at Donner summit

AMJ Cx female *tarsalis* cc
(log detrended) female *tarsalis*; 34 districts (677 sites)



JAS Cx female *tarsalis* cc
(log detrended) female *tarsalis*; 34 districts (677 sites)

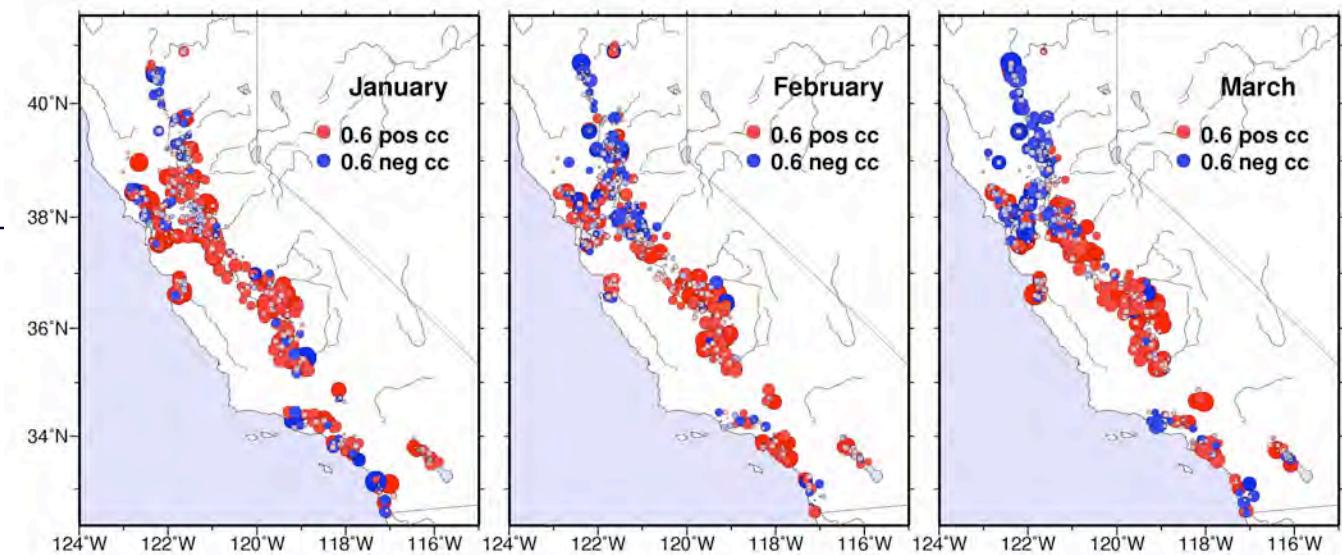




Correlations
between monthly
winter
precipitation and
spring [AMJ] or
summer [JAS] *Cx.
tarsalis* abundance

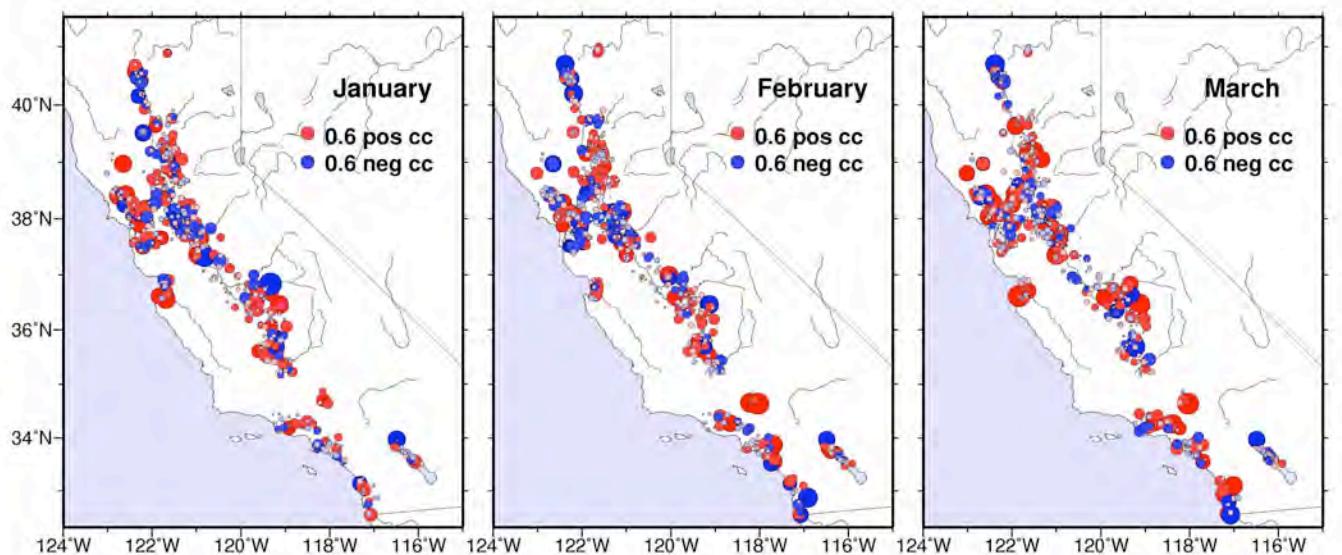
AMJ Cx female *tarsalis* **detrended** cc with Calif div precipitation

(log) female *tarsalis*; 34 districts (677 sites)



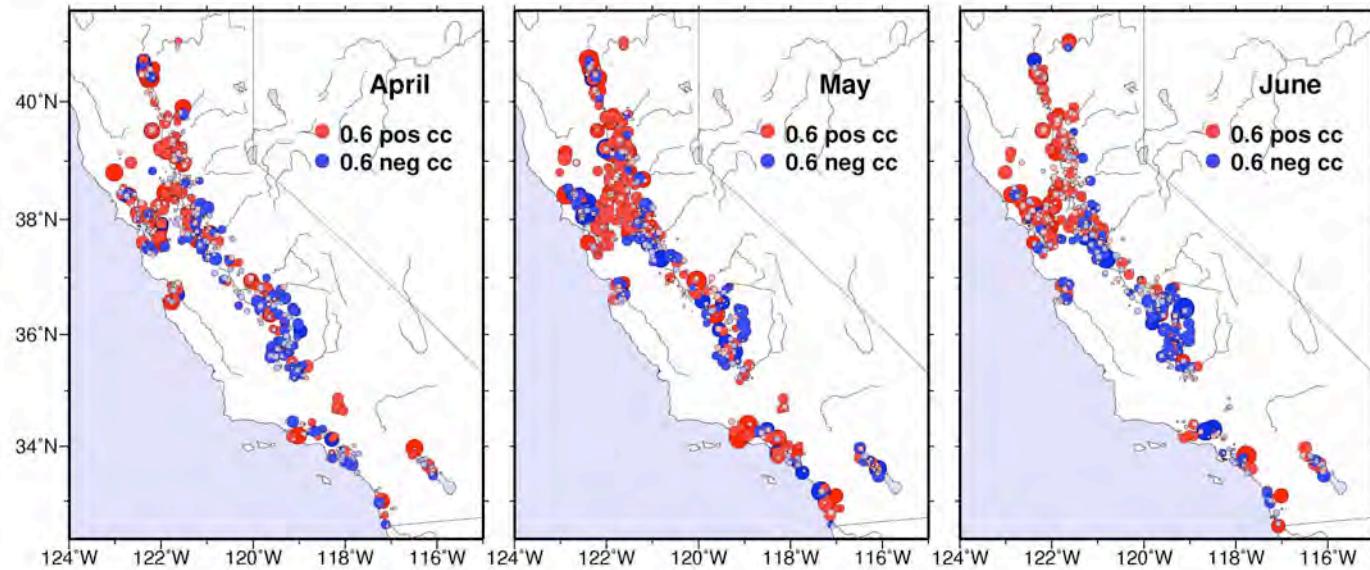
JAS Cx female *tarsalis* **detrended** cc with Calif div precipitation

(log) female *tarsalis*; 34 districts (677 sites)



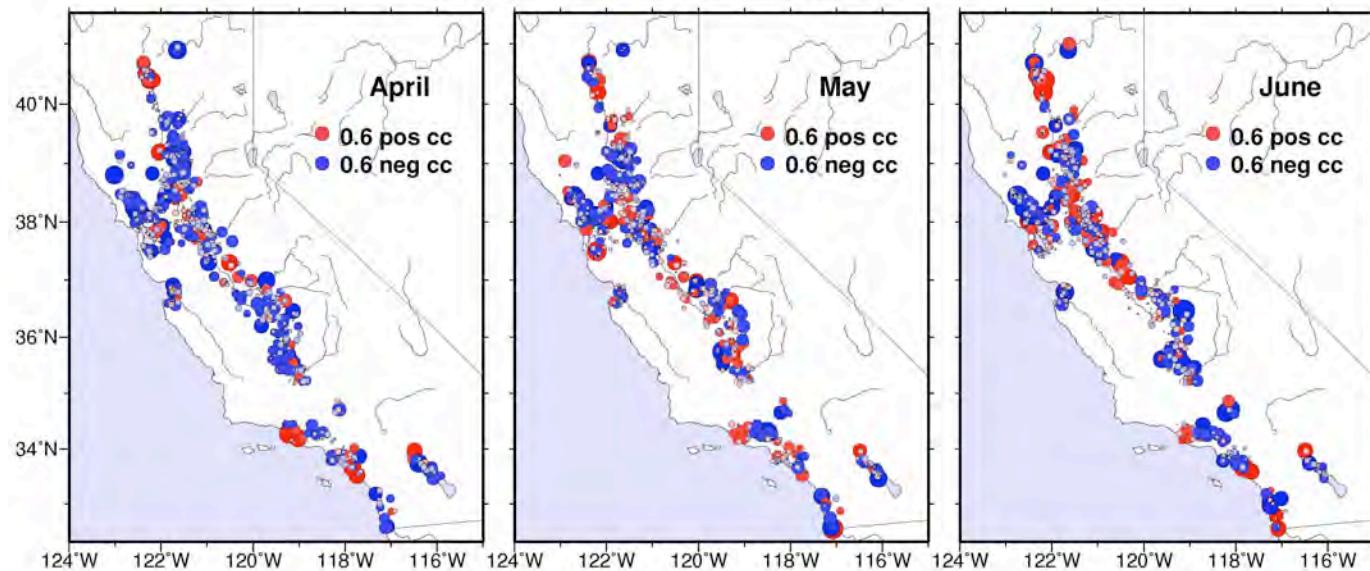


AMJ Cx female *tarsalis* **detrended** cc with Calif div temperature
(log) female *tarsalis*; 34 districts (677 sites)

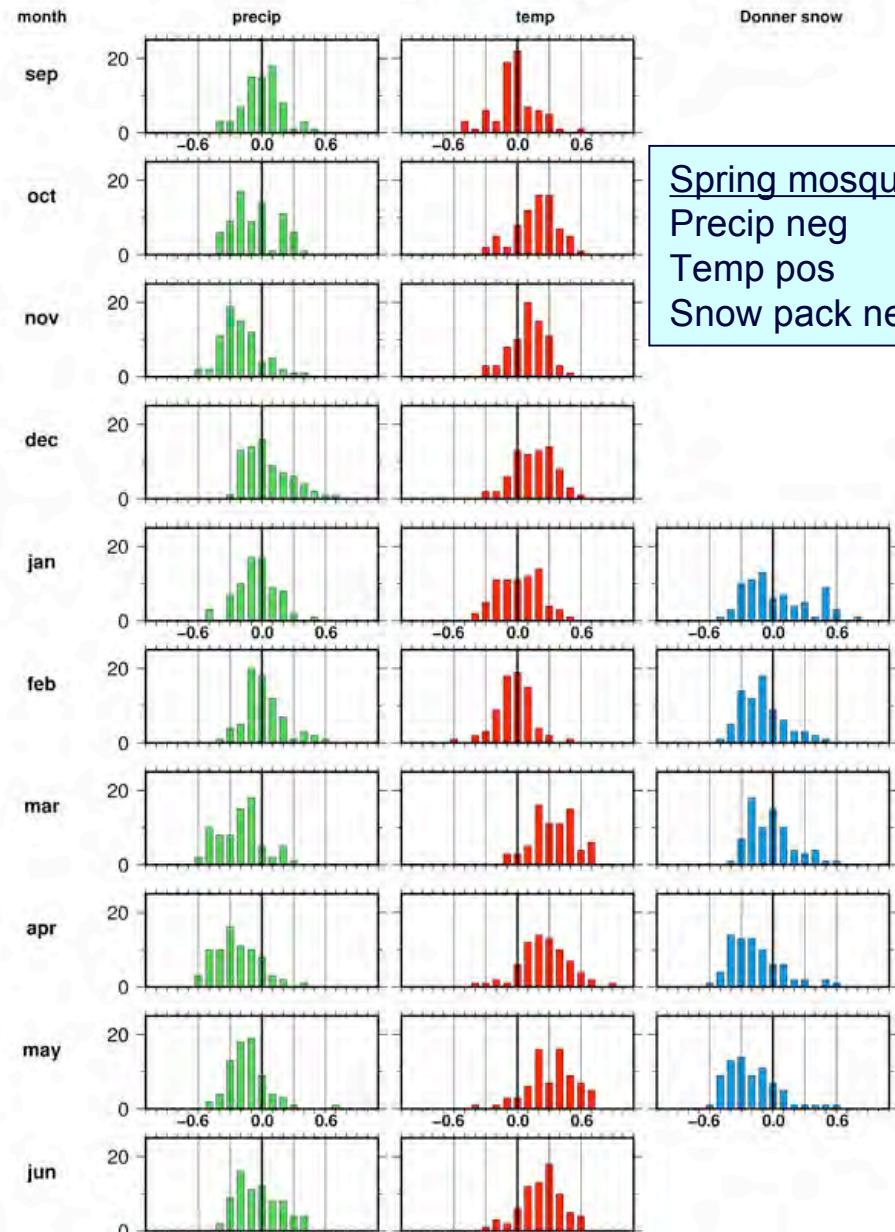


Correlations
between monthly
spring temperature
and spring [AMJ]
or summer [JAS]
Cx. tarsalis
abundance

JAS Cx female *tarsalis* **detrended** cc with Calif div temperature
(log) female *tarsalis*; 34 districts (677 sites)

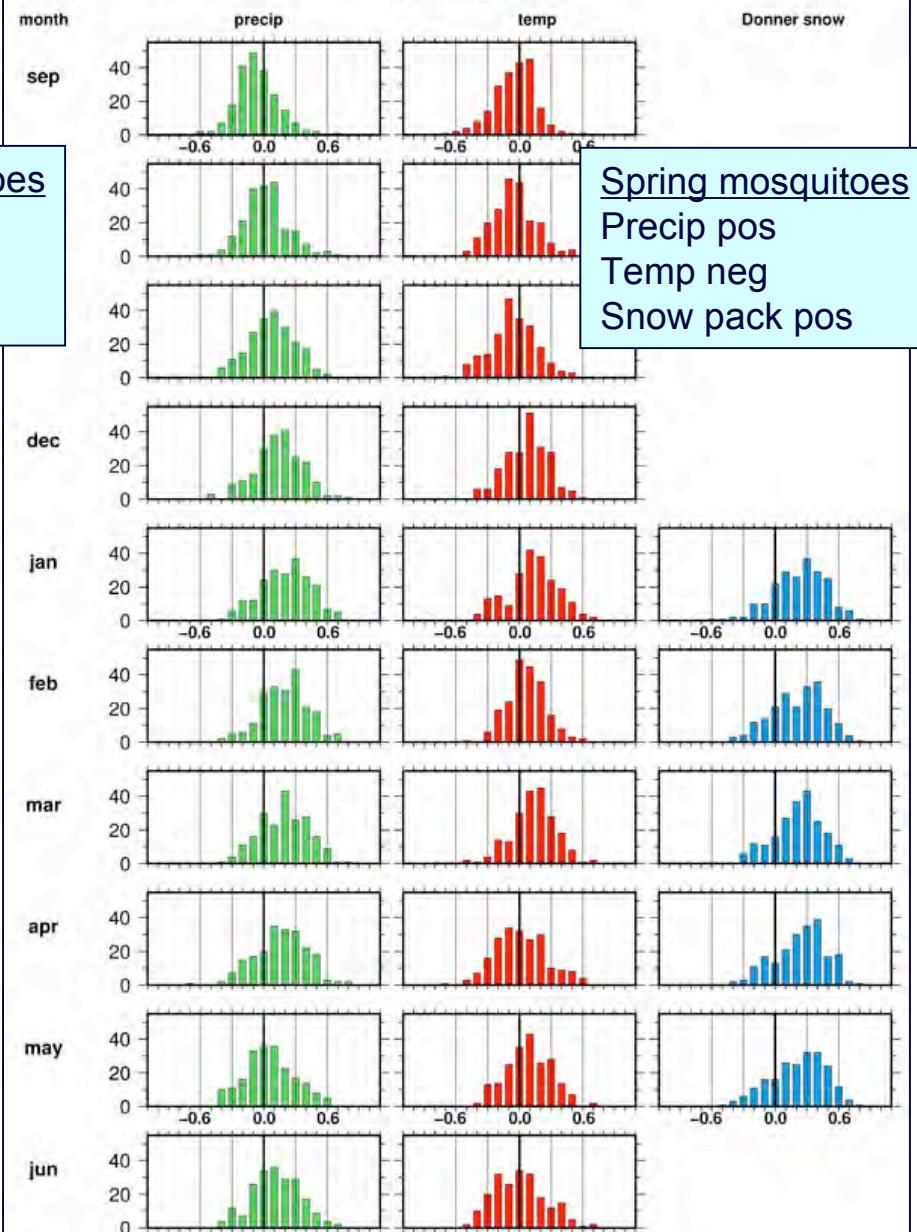


AMJ female *cx tarsalis* -- north of Sacramento -- corcof bins
log detrended (1950–2000)

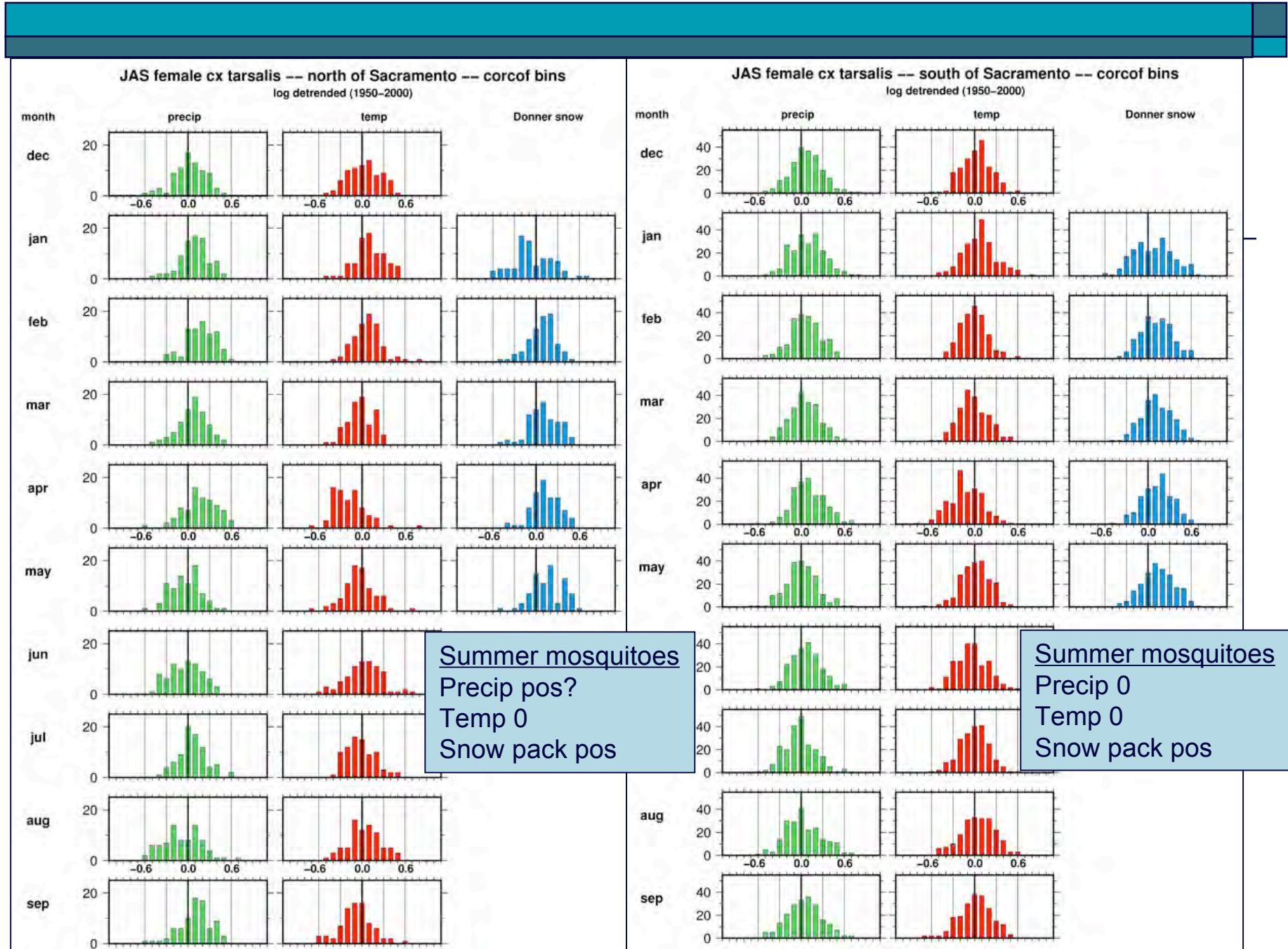


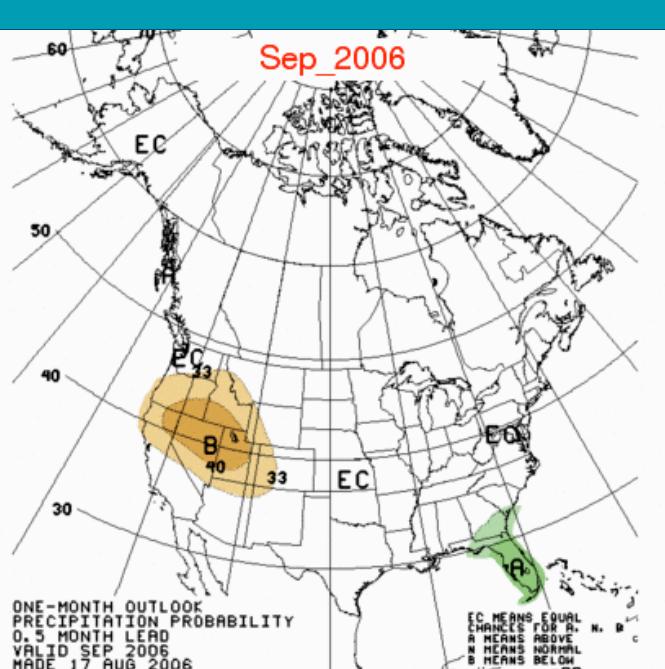
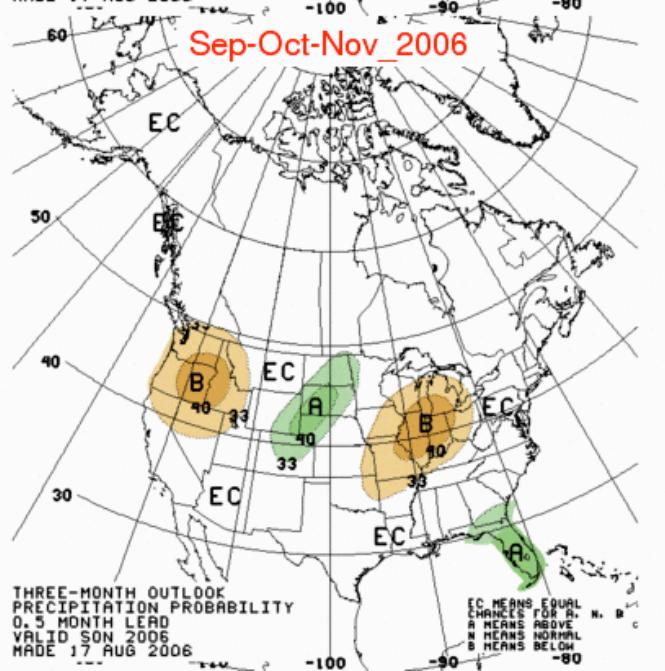
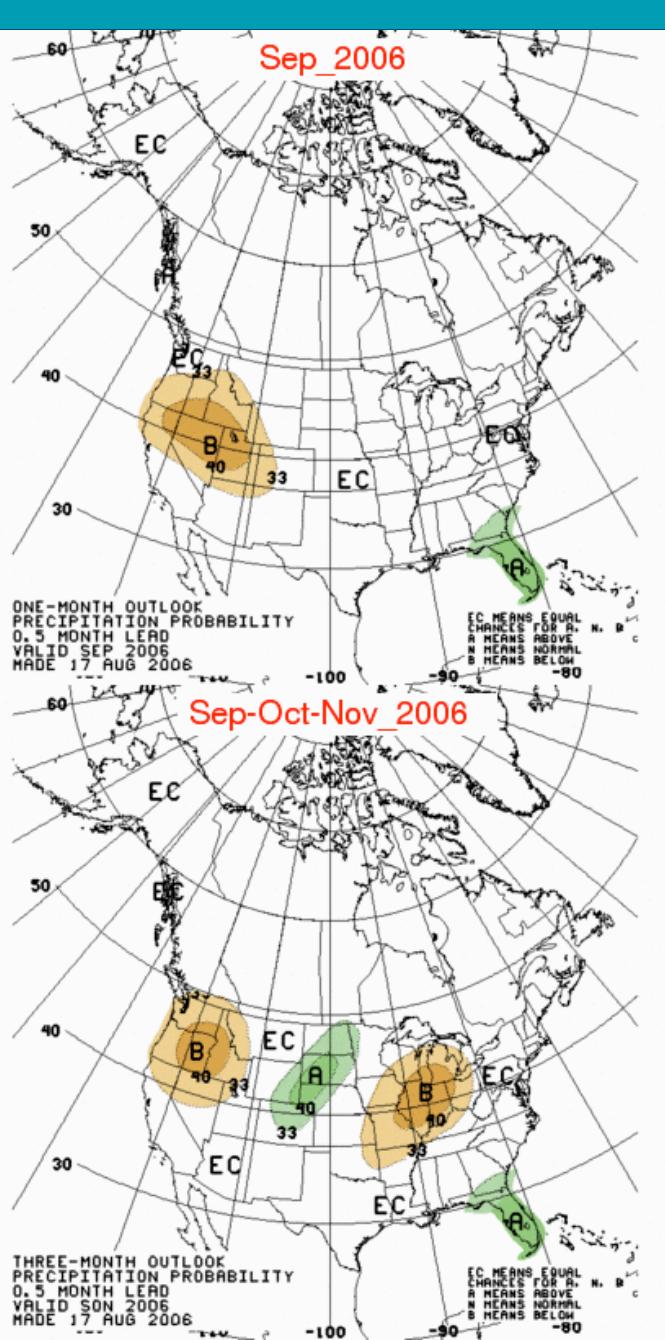
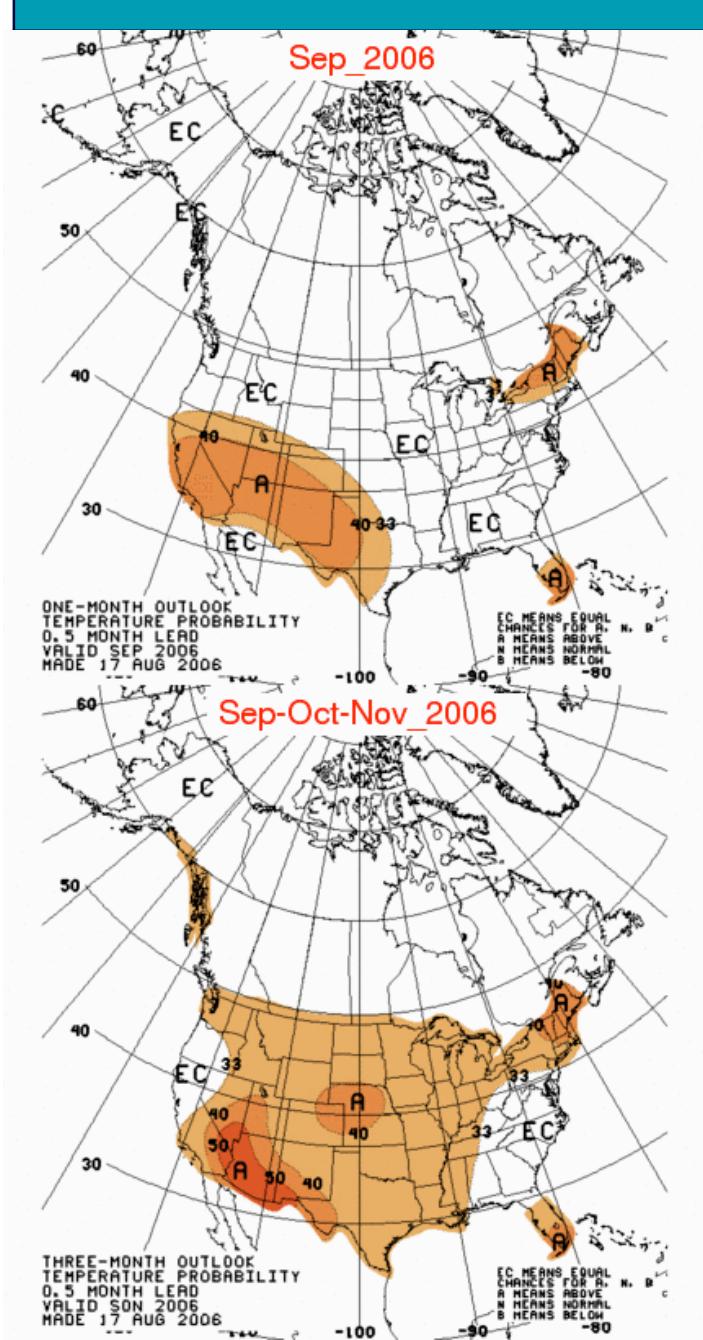
Spring mosquitoes
Precip neg
Temp pos
Snow pack neg

AMJ female *cx tarsalis* -- south of Sacramento -- corcof bins
log detrended (1950–2000)

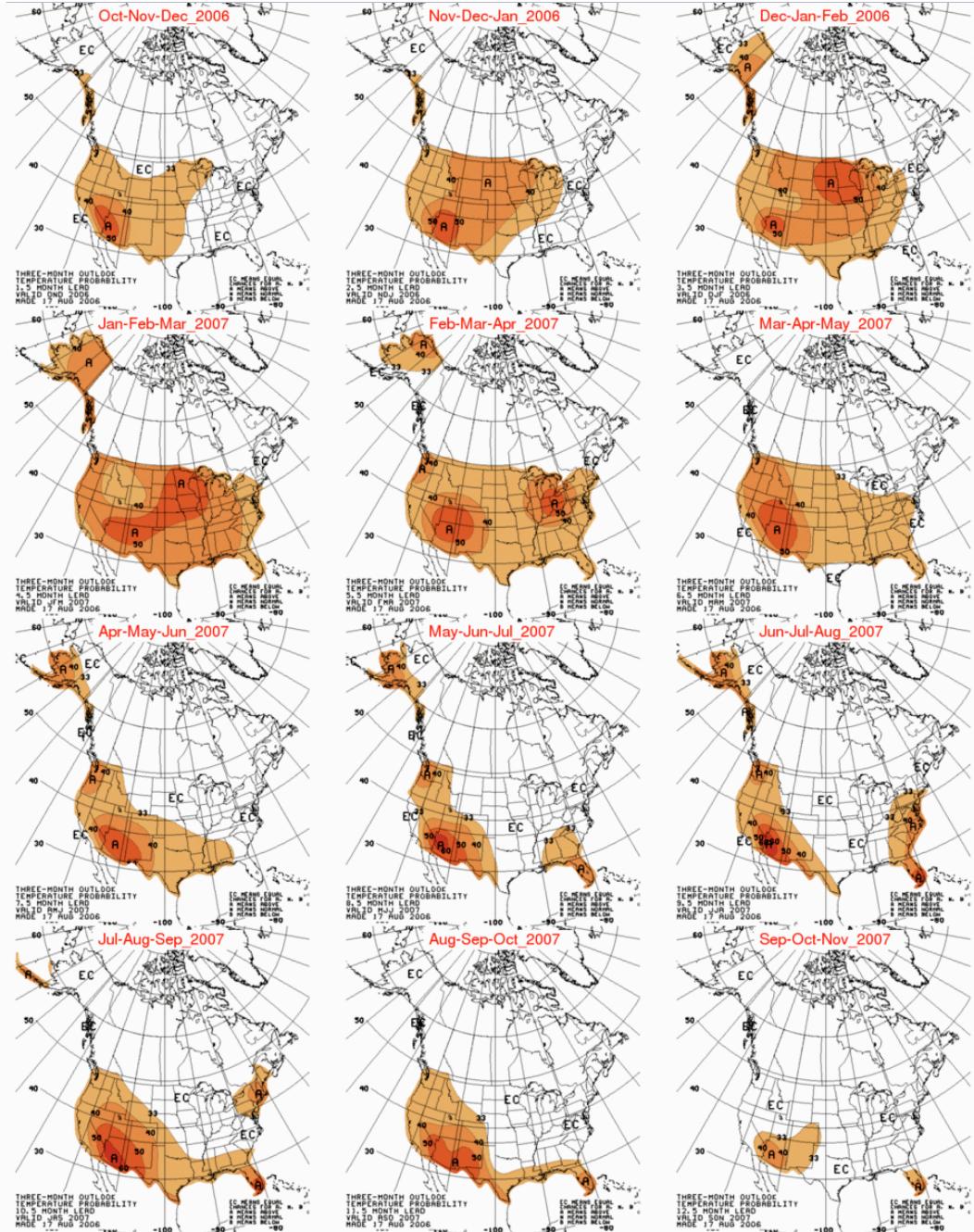


Spring mosquitoes
Precip pos
Temp neg
Snow pack pos

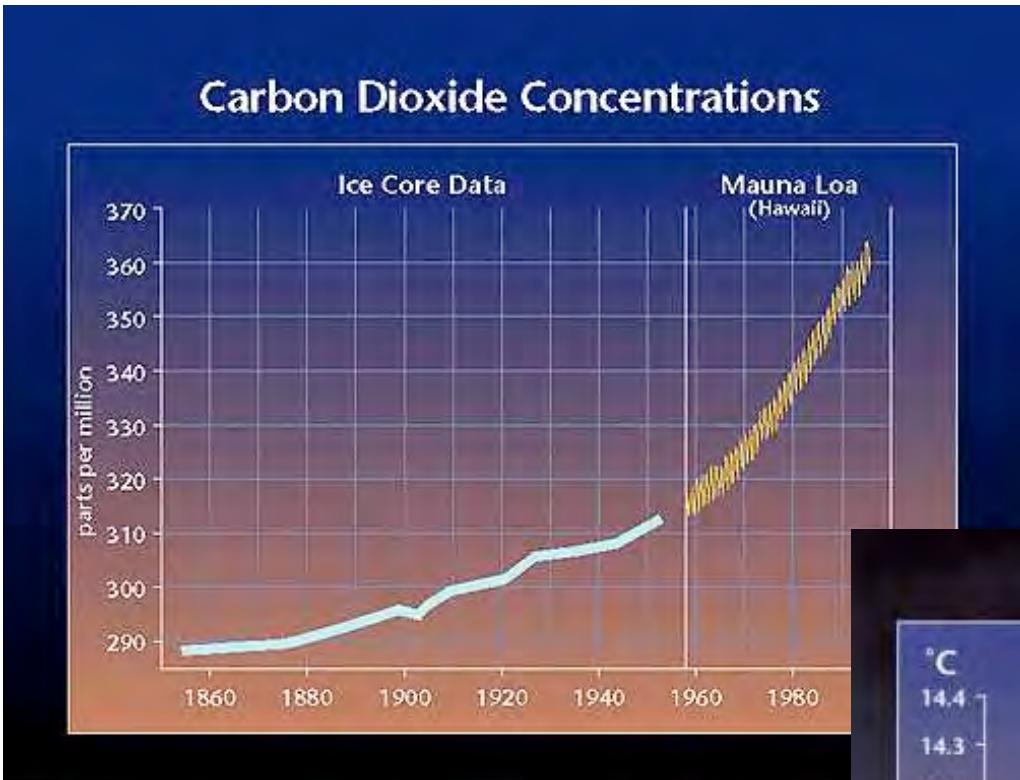




Forecast for above normal temperatures for California and the SW during the fall 2006 period – does this equate to longer virus transmission season???

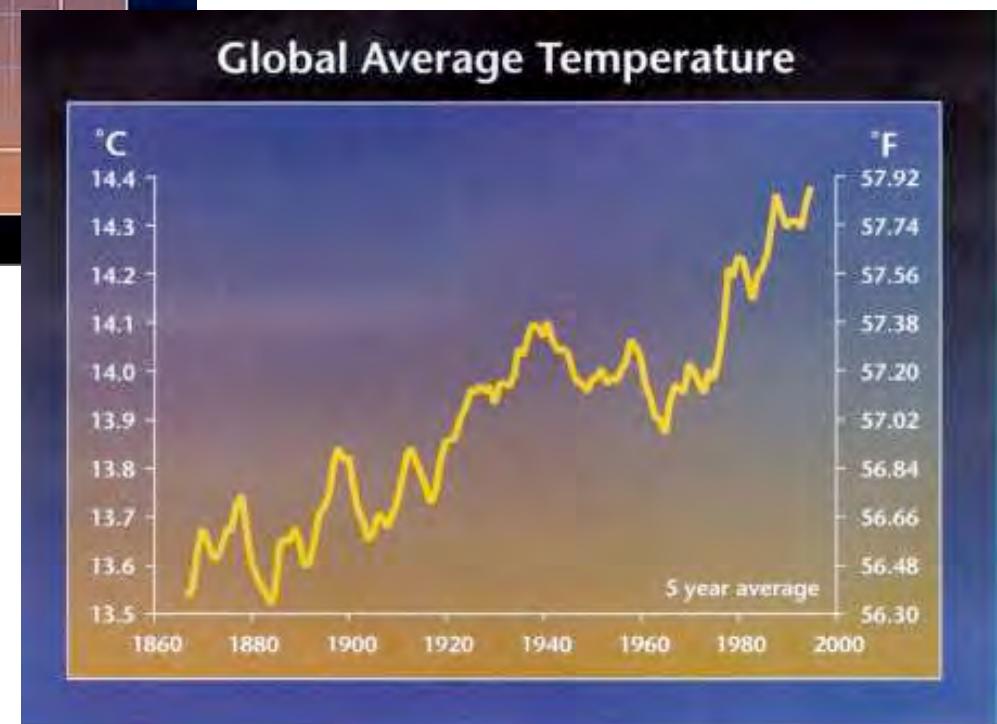


Long range forecast for the winter is for above normal temperatures for most of the USA, especially the SW.

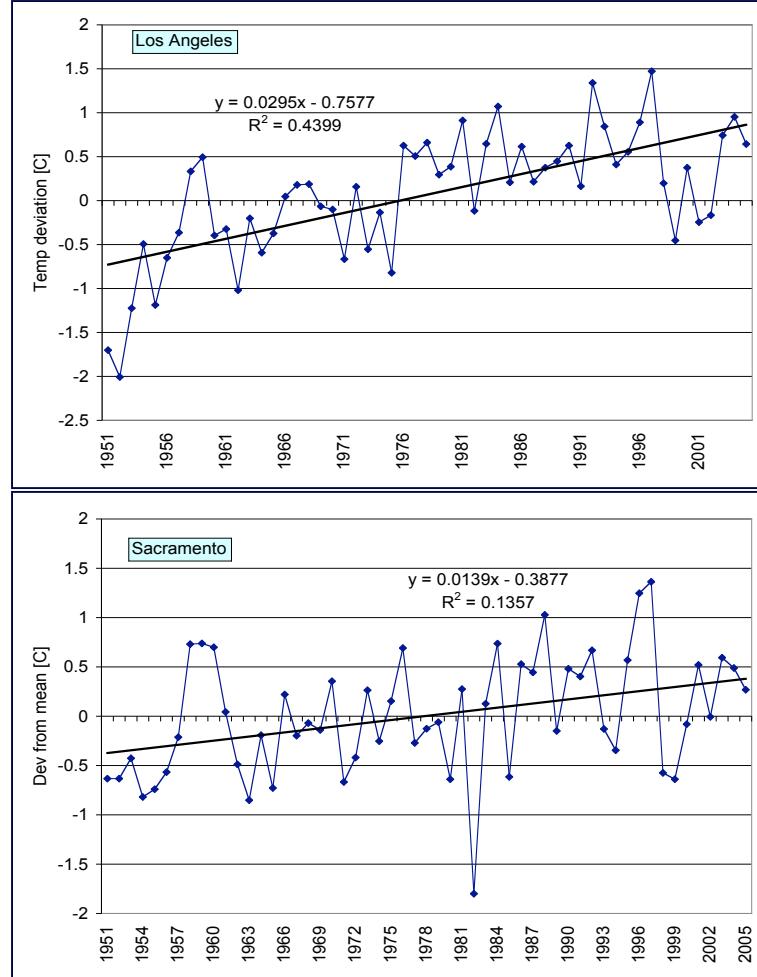
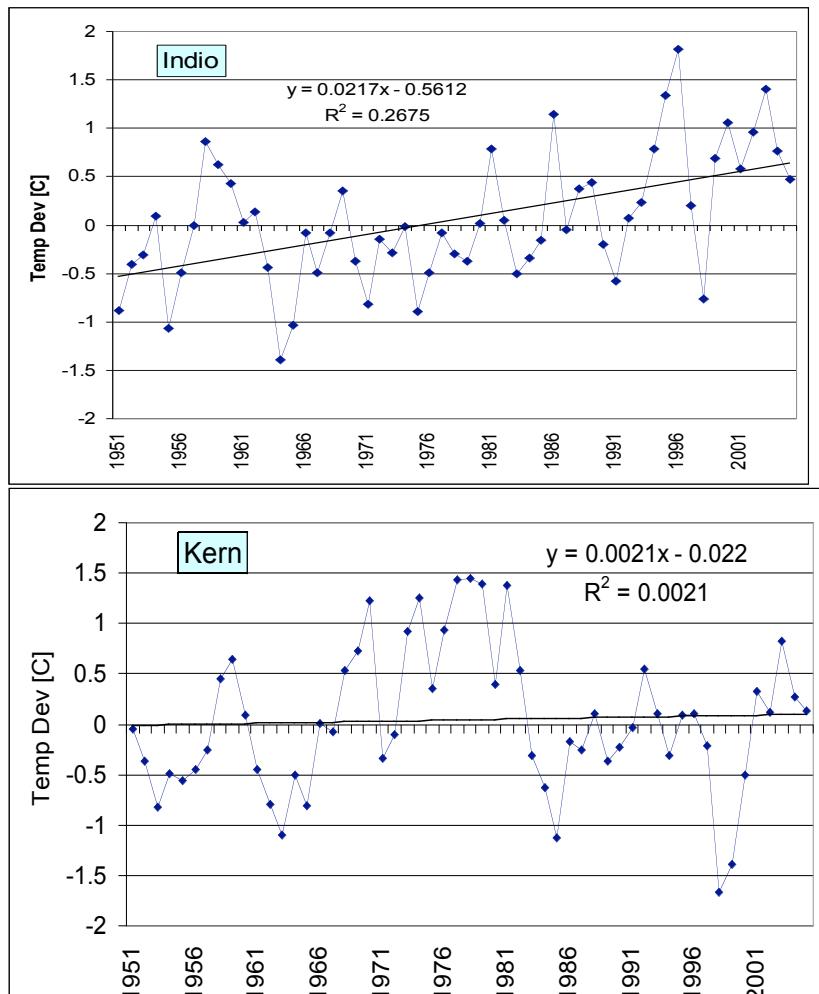


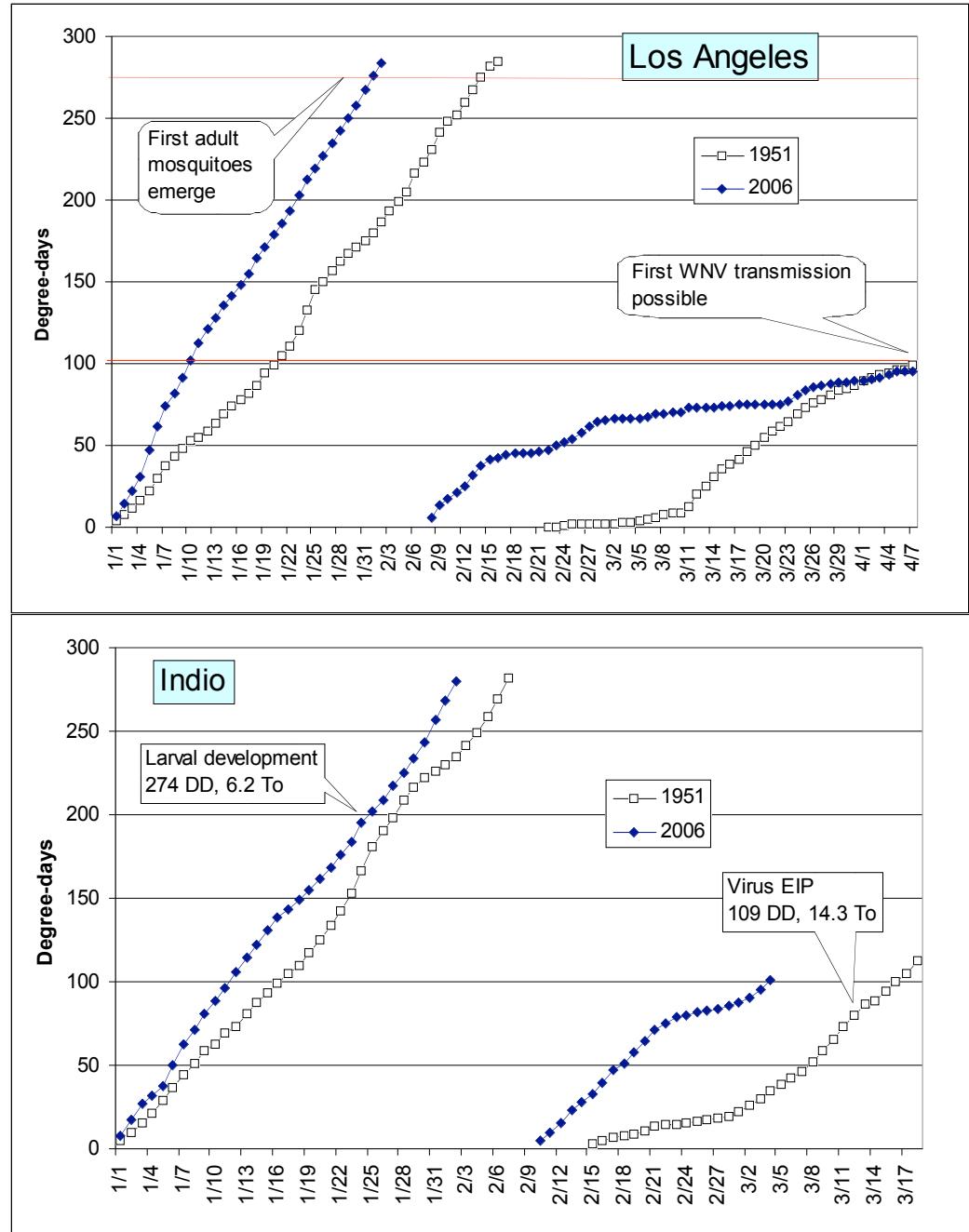
Global warming

Long term trends show global increases in green house gases and temperature



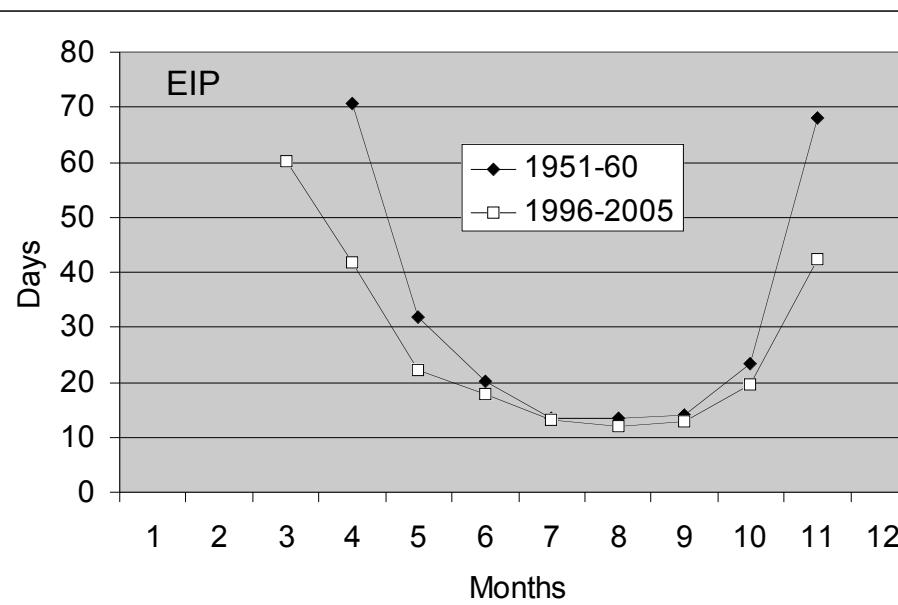
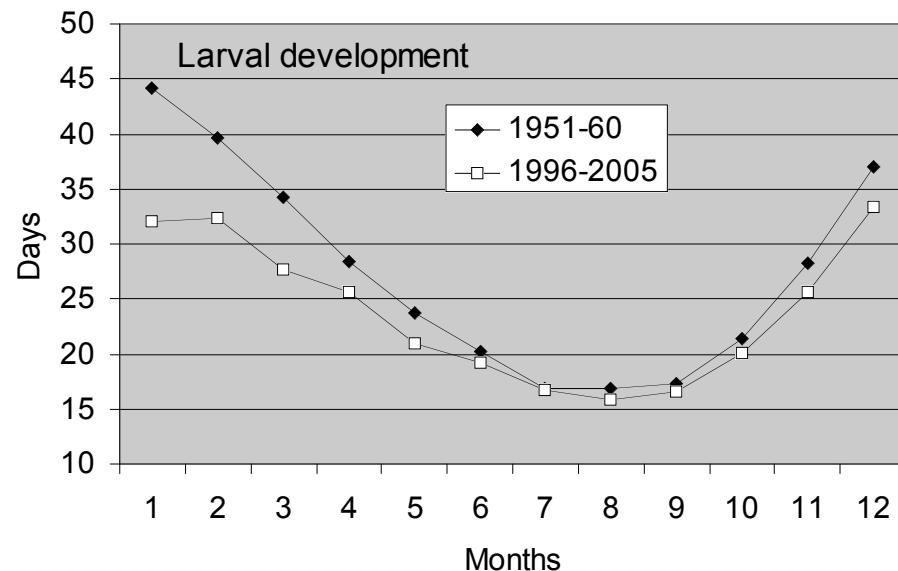
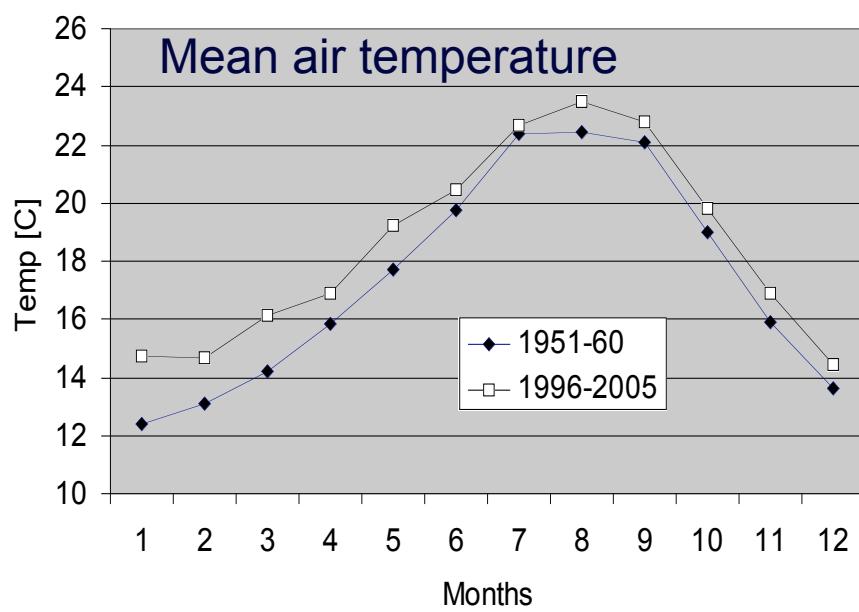
Change in temperature in California at four weather stations, 1951 - 2005



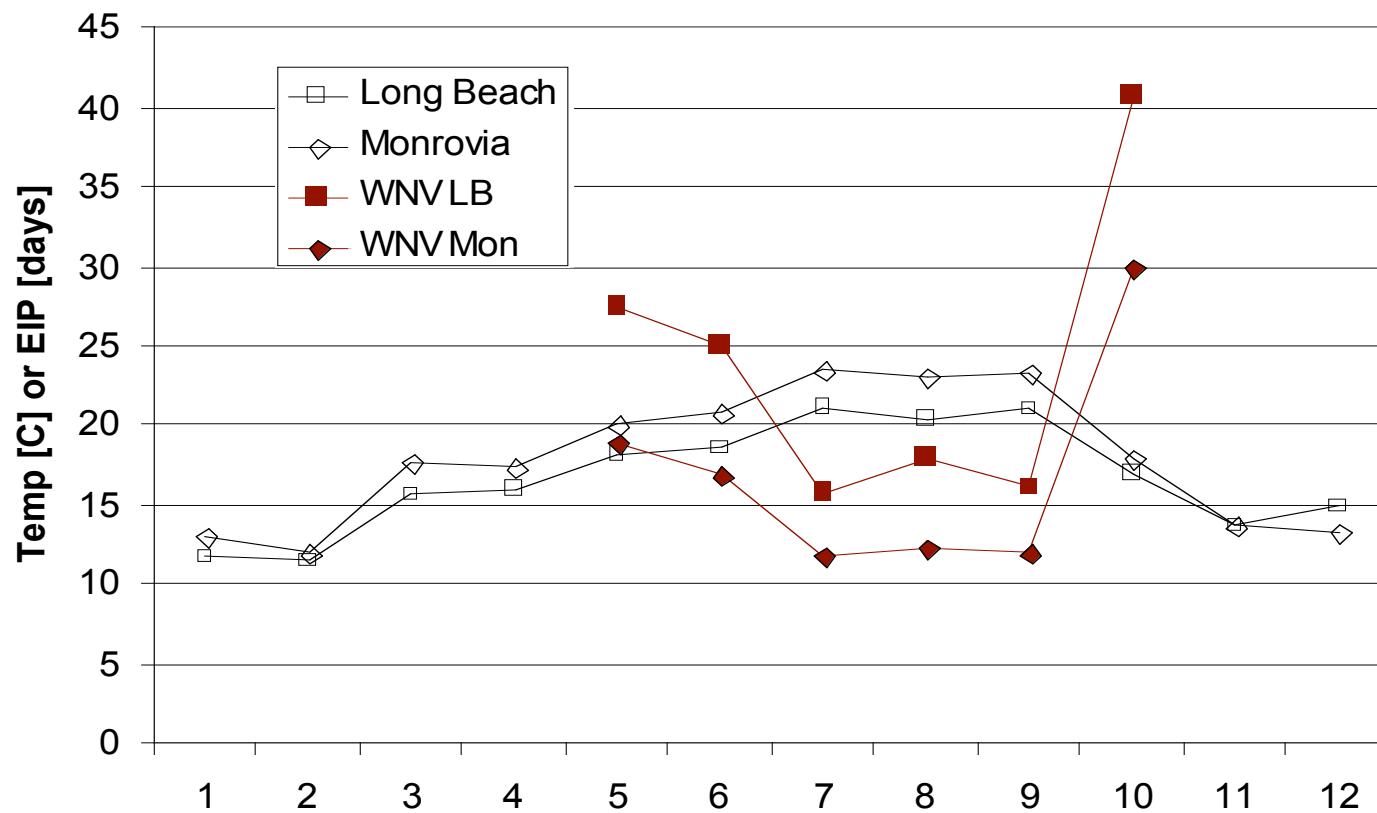


Timing of first emergence of *Culex* and first transmission of WNV in LA and Indio, 1951 vs. 2006

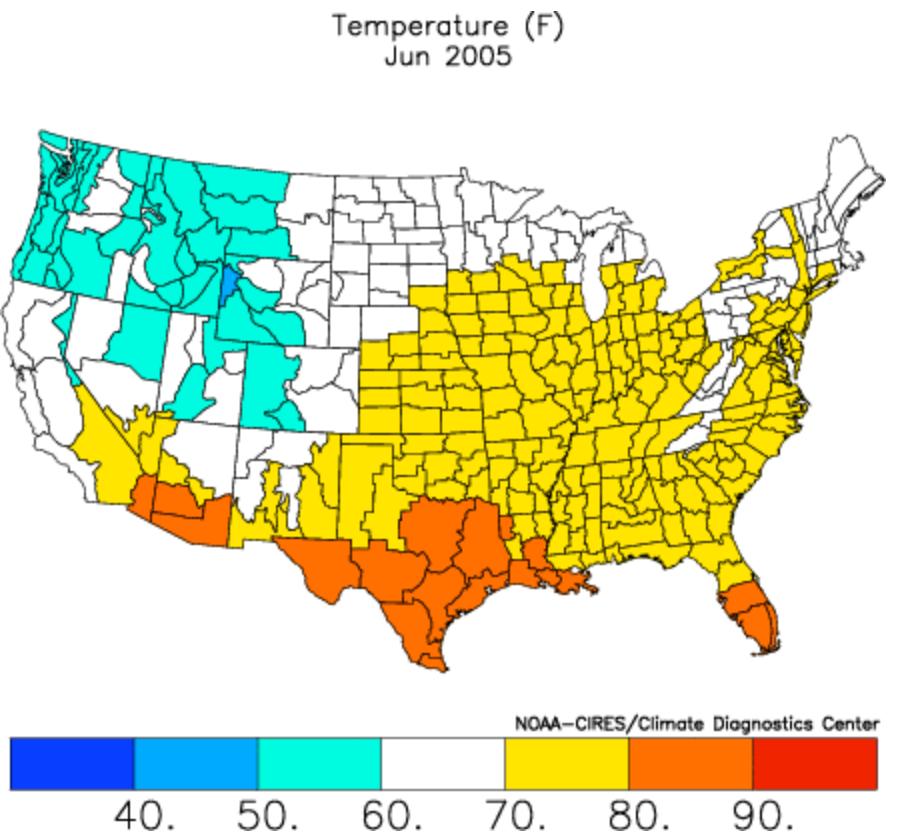
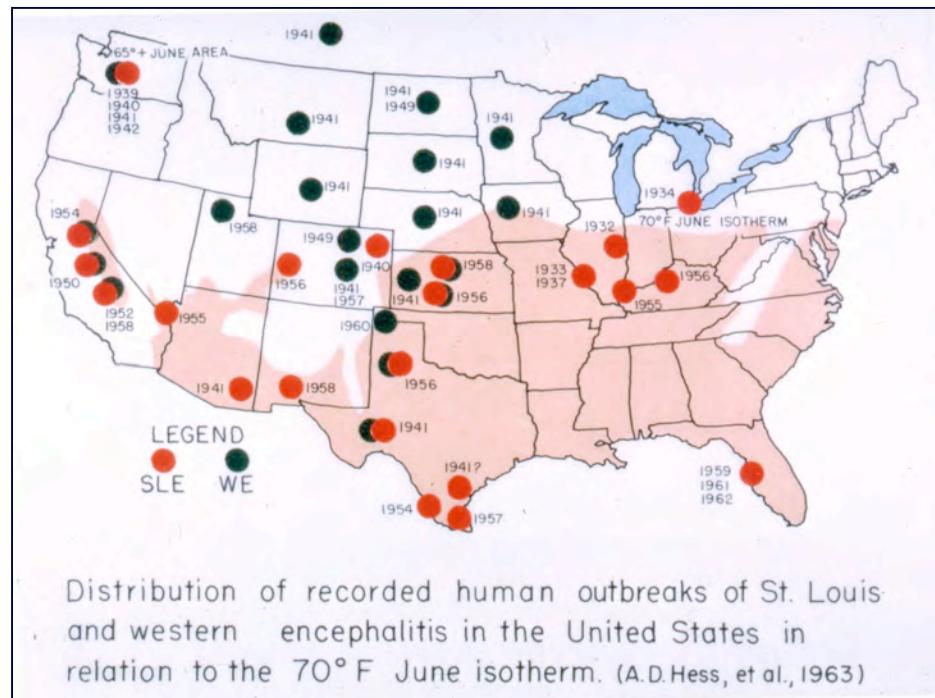
Impact of mean decadal temperature change in Los Angeles on mosquito larval development and the WNV EIP



Mean monthly temperature at two sites in LA and differences in the WNV EIP



Distribution of WEE and SLE epidemics as a function of 70F June isotherm in 1963 compared with the June 2005 70-80F range.



Summary by time scale

- Short scale ~ seasonal or “weather”
 - Hot weather increases virus transmission by
 - Rapidly increasing mosquito population size
 - shortening the EIP and GC
 - Epidemics of WNV associated with above normal temperatures
- Moderate time scale ~ decades
 - N California: AMJ temp +, ppt -; JAS: snow +
 - S California: AMJ temp -, ppt +; JAS: snow +
- Long time scale ~ global warming
 - S California sites have shown greatest increase
 - Earlier emergence date for F1 generation emergence and potential arboviral transmission
 - Northern movement of the 70F isotherm may have increased the area of the USA receptive to endemic and introduced viruses such as WNV